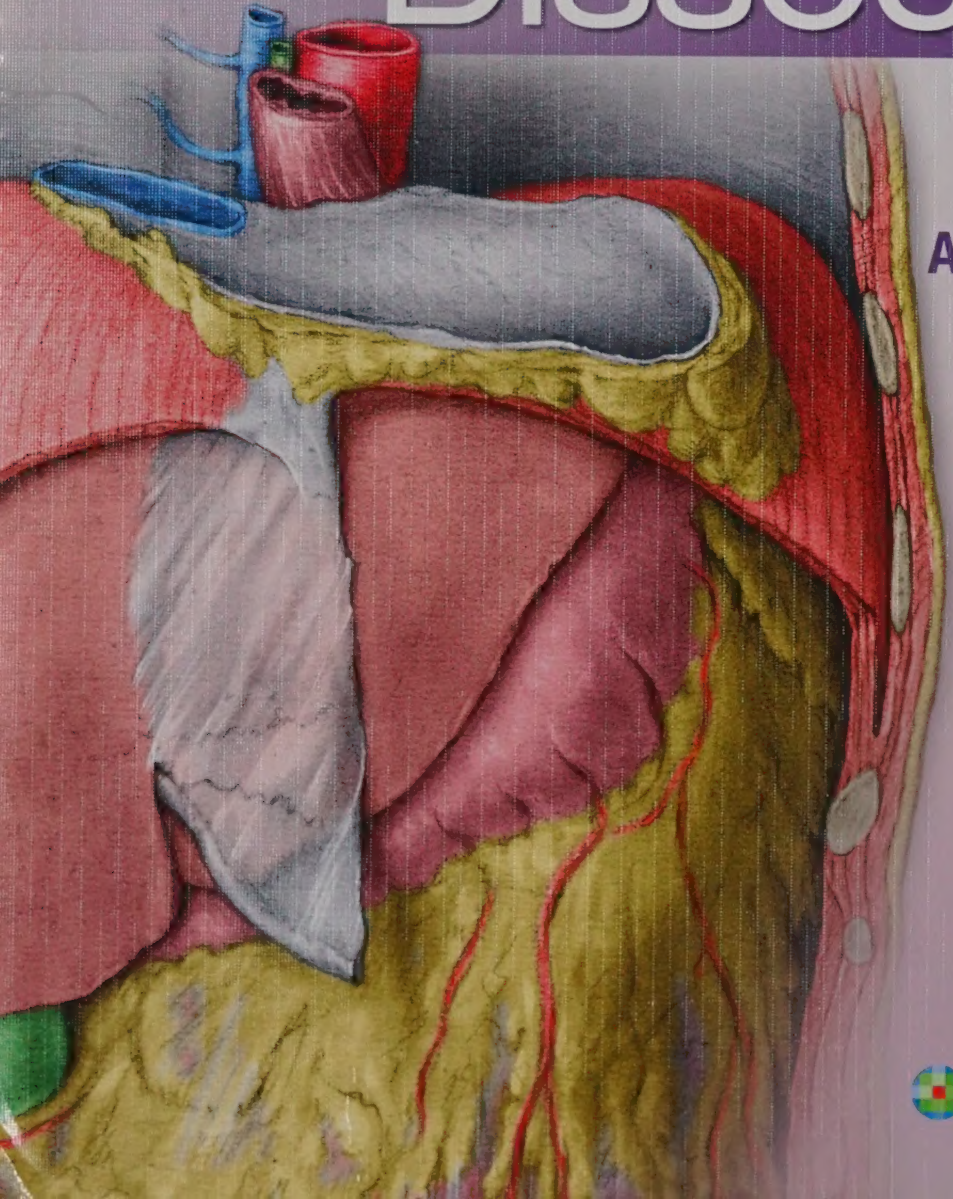
# Grant's Dissector



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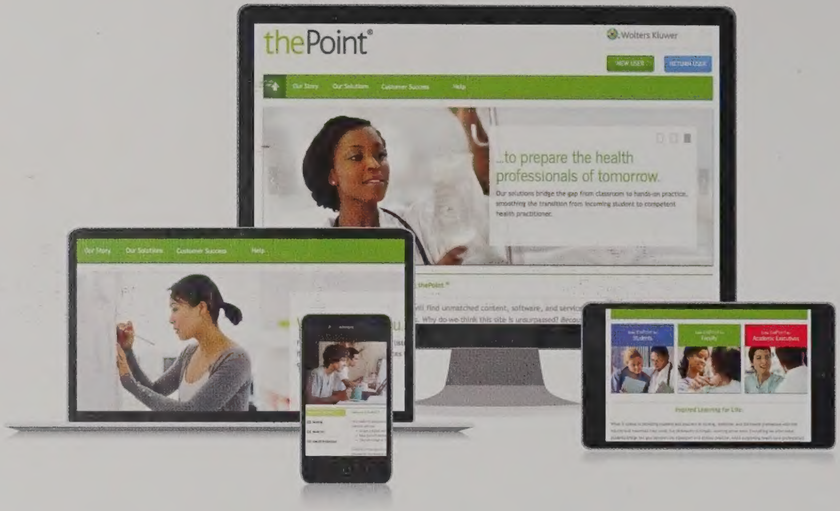
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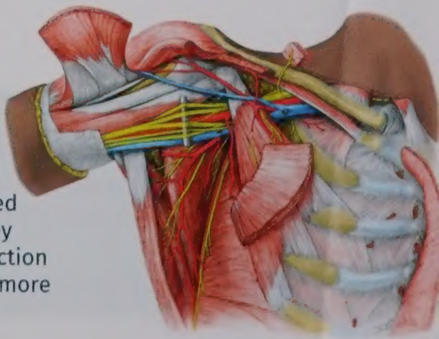

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# Grant's Dissector

## Edition 17

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*taught me so much*

*and continue to bring*

*inspiration to my life*

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*appreciation to the donors*

*who have given all*

*to the advancement of*

*education and research*

*without whom this work*

*would not be possible*

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# Preface

*Grant's Dissector* is intended to provide dissection instructions and enough anatomical detail to help students observe and recognize important relationships revealed through human dissection. The seventeenth edition of *Grant's Dissector* aims to continue the strong tradition of previous editions as a regional dissection instruction manual with an emphasis on streamlining the content for today's gross anatomy courses. As curricula are constantly changing, the modifications described here are intended to increase the adaptability of *Grant's Dissector* to a variety of dissection needs while maintaining an appropriate level of depth.

## UNIT ORGANIZATION

The organizational flow in the seventeenth edition has been modified to maintain consistency throughout every chapter. The chapters are subdivided into units, which begin with a clearly labeled title and short summary of the region of interest followed by three key aspects to each dissection: an overview, the instructions, and a follow-up.

### Dissection Overview

#### Clinical Correlations

The start of each chapter now includes a summary list of the clinical correlations found throughout the text alongside the supplemental figure references from *Grant's Atlas of Anatomy*. The list of clinical correlations sites the heading and subheading locations of the blue box content found within each chapter. The newly provided list is meant to provide a quick point of reference for students interested in the application of anatomical knowledge in the clinical setting, a key component to clinical gross anatomy instruction. Preceding the list of correlates in each chapter, students are reminded that they may encounter anatomical variations, clinical conditions, disease processes, or medical devices in their cadaveric donors.

#### Skeletal and Surface Anatomy

The dissection overview introduces what is to be accomplished during the dissection session and includes step-by-step instructions to guide students through the relevant skeletal anatomy subdivided topically, followed by applicable surface anatomy. Commencing a dissection with the relevant skeletal features is meant to reinforce their anatomical relevance and lay a foundation for the surface anatomy that is then palpable on the cadaver. Similar to a clinical exam, a proper understanding of the skeletal and surface landmarks plays a key role in comprehension of the underlying anatomy during a dissection.

### Dissection Instructions

#### Figure References

A major change in the seventeenth edition is the manner in which the figures of the text are used within the dissection instructions. Previously, highlighted anatomical terms had been individually sited in reference to figures in the dissector as well as other atlas illustrations. Though many terms were given specific attention via references, others were often repeated or missed entirely. To streamline the text, all dissection overview and dissection instruction sequences begin with a figure reference for the anatomical terms included in the subsequent instructions. The streamlined method is meant to facilitate student comprehension of the association of multiple structures, minimize the amount of back and forth figure referencing, and provide a much higher association of all bolded terms to the presented figure.

#### Skin Removal

A significant modification in the seventeenth edition is the manner in which removal of the skin may be approached in the dissection sequences. Students may now select to completely remove the skin or to reflect it to the periphery of the region of interest as well as adjust the depth at which the process may be performed. To clarify the various techniques, the introduction material now provides definitions for *skin removal* versus *skin reflection*, as well as full- and partial-skinning techniques corresponding to a new figure. Additionally, each dissection sequence related to skinning now offers updates to the colors used in the figures for required versus optional cut lines for improved clarity.

### Dissection Follow-up

#### Cadaver Care

The Introduction of the text begins with a description of the students' "first patient" and the responsibility to properly care for the donor's remains with a section on cadaver care. Each dissection sequence ends with a Dissection Follow-up and includes a numbered list of tasks for the students to perform in the lab following the dissection and reminds students of proper care and cadaver maintenance throughout the entire dissection protocol. The numbered tasks also highlight the important features of the dissection and encourage the synthesis of information through review of the material.

### Muscle Summary Tables

The 33 muscle summary tables introduced in the sixteenth edition in the Dissection Follow-up have been maintained and improved for accuracy in the seventeenth edition. The muscle summary tables provide succinct information related to muscles names, attachments, actions, and innervations of the key muscles identified during each dissection unit. The muscle tables provide a key review opportunity for students, while simultaneously making the dissections steps in the instructions more task oriented and approachable.

## KEY FEATURES

### Figure Labeling

In addition to the effort taken to correlate instruction and terms to the figures presented, significant care was made to maintain consistency throughout the figure labels. In the seventeenth edition, key abbreviations were used to minimize text in the figures. The terms *artery*, *arteries*, *vein*, *veins*, *nerve*, and *nerves* were replaced with the abbreviations a., aa., v., vv., n., and nn., respectively. Additionally, the term *muscle* or the abbreviation of m. was removed from the labels to decrease redundancy, improve label clarity, and provide increased consistency throughout the text. A new summary table of the abbreviations and lines used in the figures of the text is now featured in the Introduction chapter for reference.

### New Illustrations

Several new illustrations were either used as replacements for previous illustrations or added to clarify the intent of the descriptions in the text and to assist the student in making correct incisions and dissection procedures. Particularly new multiview illustrations for complex dissection protocols such as the hemisection of the pelvis and skull have been added. In total, 76 images were modified, altered, updated, or added to the existing illustration collection.

## ADDITIONAL RESOURCES

References to companion atlas and video material in the seventeenth edition of *Grant's Dissector* are now consistently listed next to the correlating section headings. In the printed text, two primary resources have been highlighted for supplemental instruction: *Grant's Atlas of Anatomy* (Atlas) and *Grant's Dissection Videos* (Video).

### References to Atlas Illustrations

The student is encouraged to rely on *Grant's Dissector* for dissection instruction and to use *Grant's Atlas of Anatomy* for additional portrayal of anatomical structures. To facilitate figure searching, atlas references now refer to specific figure numbers rather than page numbers as seen in previous editions.

- Agur AMR, Dalley AF. *Grant's Atlas of Anatomy*. 15th ed. Philadelphia, PA: Wolters Kluwer; 2021.

### References to Dissection Videos

A companion series of high-definition videos was released with the publication of the sixteenth edition of *Grant's Dissector*. Each dissection instruction protocol of the *Grant's Dissection Videos* was performed, filmed, and edited by the author, Dr. Alan J. Detton, in a series of approximately 80 videos paralleling the instructions for each region of the body. The dissections were performed on a single male and single female cadaver, to replicate the dissection experience encountered by students within the laboratory environment. The seventeenth edition now includes time stamp indicators for the correlating sequence of video footage within the *Grant's Dissection Videos* throughout the text.

# Acknowledgments

The creation of the seventeenth edition of *Grant's Dissector* would not have been possible without the support and assistance from an incredible group of individuals. Through the writing of this text, I have realized that it is one thing to accomplish a task and entirely a different experience to try and not only repeat the task but hopefully improve on the previous results.

I realize that first and foremost, I need to express my gratitude for the significant contributions of authors involved in the development of previous editions of *Grant's Dissector*. I now better understand the effort that Dr. Patrick Tank and previous colleagues invested as authors of this text and more than ever appreciate the body of work that I am honored to work with. I'd like to express my gratitude for the support I've felt from numerous colleagues and mentors within the field of anatomy as I've worked on the *Grant's* brand, it truly has been remarkable, and I hope someday to mentor as I've been mentored. In particular, I want to express my gratitude for the warm support, advice, and collegiality that I've felt from Drs. Anne M. R. Agur and Arthur (Art) F. Dalley. You have positively influenced my efforts more than you may know with whom you are as individuals, and I remain deeply impressed with how you've been able to share your love and passion for anatomy with the world. I want to thank Dr. William (Bill) Schwartz for the detailed notes and feedback provided through each chapter to make this a more accurate resource. Your attention to detail and identification on points benefiting from clarity was immensely helpful as the worked progressed, and you are due credit for your expertise and content knowledge in the anatomical field. Additionally, I would again like to thank Dr. Sherry A. Downie for the major contributions made in the previous edition and for her continued support and mentoring with this most recent edition.

I wish to express my sincere thanks to the team at Wolters Kluwer for continuing to trust me with such an ambitious undertaking on such a prominent piece of work. Crystal Taylor, you are amazing, and I thank you for your ongoing reception of my thoughts and ideas throughout the duration of this project. Greg Nicholl, I can't thank you enough for the extended and significant help along the path to publication for a now second-time author. I have not expressed sufficiently my gratitude to you for all the time, patience, and constructive advice you have given and hope to work with you in the future on additional projects. Jennifer Clements, the magnificent art director for this text, and Rob Duckwall, our medical illustrator, you have gone above and beyond as we progressed toward a more consistent and cohesive body of work. Your work is recognized and greatly appreciated.

Lastly, thanks to the many individuals, students, instructors, mentors, and colleagues who supported me along this most recent leg of my life journey at the University of California, San Francisco; University of California, San Diego; Columbia University; and elsewhere.

Alan J. Detton

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# Introduction

## YOUR FIRST PATIENT

The opportunity to dissect a human body is a once in a lifetime experience. It is not possible to fully appreciate the motivation of an individual to become a body donor, but most of us will try to imagine the circumstances that lead to that decision. The value of the gift that has been given to you cannot be measured and can only be repaid by the proper care and use of the cadaver. The cadaver must be treated with the same respect and dignity reserved for the living patient. It is recommended that prior to commencing dissection, a moment be taken to consider the life of your donor, the incredible gift your donor had provided for your education, and the proper amount of care and respect you wish to honor your donor with during the dissection.

## CADAVER CARE

Upon entering the laboratory, you will find that the cadaver has been embalmed with a strong fixative. The whole body has been kept moist by wrappings, submersion under preservative fluid, or a body bag. Desiccation of the cadaver will make the specimen much more difficult to work with and study because once a part has been allowed to become dry, it can never be fully restored. Therefore, expose only those parts of the body that you are currently working on and moisten any exposed regions periodically throughout the dissection. At the end of each dissection session, moisten the wrappings and the cadaver with wetting solution and properly cover the cadaver following the protocols of your laboratory.

## DISSECTION INSTRUMENTS

It is generally true that large dissection equipment (hammers, chisels, saws, etc.) will be provided for you, but personal dissection instruments may need to be purchased. The well-equipped dissector should have the following instruments (FIG. I.1):

- **Probe**—an excellent blunt dissection tool to be used for investigation of a new region along with your fingers. A probe is designed to tear connective tissue and allow the user to feel nerves and vessels before they are damaged.

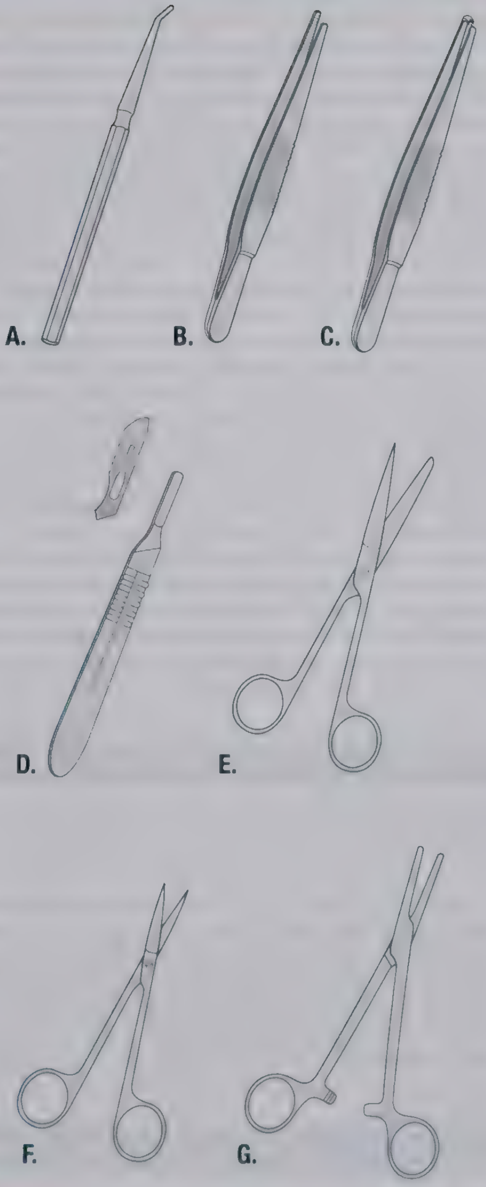


FIGURE I.1 ● Dissection instruments. **A.** Probe. **B.** Forceps. **C.** Tissue (rat-toothed) forceps. **D.** Scalpel handle and blade. **E.** Large blunt-ended scissors. **F.** Small sharp-ended scissors. **G.** Hemostat.

With practice, the probe can become a primary dissection instrument to isolate and clean delicate structures.

- **Forceps**—used to lift and hold vessels, nerves, and other structures while blunt dissecting with a probe. Two pairs of forceps are needed. One pair should have tips that are blunt and rounded, and the gripping surfaces should be corrugated. The second pair should have teeth (also known as tissue forceps or rat-toothed forceps) for gripping tissue.
- **Scalpel**—primarily used as a skinning tool. Scalpels are not recommended for general dissection because they cut small structures without allowing you to feel them. The scalpel handle should be made of metal (not plastic). The blade should be about 3.5 to 4 cm long. The cutting edge must have some convexity near the point. The scalpel should be held in a grip similar to holding a pencil, and a sharp blade must be used at all times for most effective implementation. Therefore, a sufficient supply of blades will be needed. To avoid injury, seek assistance the first time you place and remove a scalpel blade.
- **Scissors**—useful in cutting, blunt dissection, and transection. Two pairs of scissors are recommended: a large, heavy pair of dissecting scissors (about 15 cm in length) and a small pair of scissors with two sharp points for the dissection of delicate structures.
- **Hemostat**—a powerful grasping tool that is helpful in skin removal. The advantage of hemostats is the ability to lock the grip on the slippery surfaces such as skin to facilitate reflection or removal of tissue. However, the hemostat has two disadvantages: First, it crushes delicate structures. Second, it cannot be repositioned quickly like forceps can, thereby slowing progress. Hemostats and scissors should be held with the thumb and fourth finger in the finger loops for the most control and precision.

## GLOSSARY OF DISSECTION TERMS

This dissection manual repeatedly uses a number of dissection terms. Before beginning to dissect, learn the meaning of the following:

- **Dissect**—to cut apart. In the context of this dissection manual, the meaning of dissect is to tear apart or separate. The recommended dissection approach throughout this manual is blunt dissection. The scalpel should only be used for skin incisions or as a tool of last resort for crude cuts to dissect extremely tough connective tissues.
- **Blunt dissection**—to separate structures with your fingers, a probe, or scissors by tearing (not cutting) connective tissues.
- **Scissors technique**—a method of blunt dissection in which the tips of a closed pair of scissors are inserted into connective tissue and then opened, tearing the connective tissue with the back edge of the tips. The scissors technique is an effective way to dissect vessels and nerves as illustrated in FIGURE I.2.

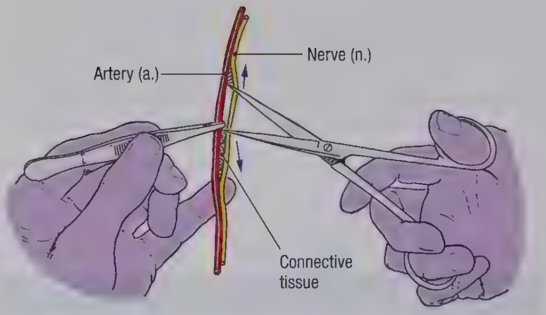

Nerve (n.)
Artery (a.)
Connective tissue

FIGURE I.2 ● Scissors technique for separating structures with blunt dissection.

- **Sharp dissection**—to dissect by use of a scalpel or the cutting edge of the scissors. The scalpel or scissors should only be used in conjunction with forceps.
- **Clean**—to remove fat and connective tissue, by means of blunt dissection (preferred) or sharp dissection, to expose the surface of an anatomical structure for study. Tissue from the surface of a structure can be removed by sharp dissection by cutting through the fascia and connective tissue after it has been separated from the desired structure with blunt dissection.
  - **Clean the surface of a muscle**—to remove all fat and connective tissue so that the muscle fascicles become obvious and the direction of force can be understood.
  - **Clean the border of a muscle**—to define the border of a muscle with blunt dissection by breaking the loose connective tissue that binds the muscle to surrounding structures.
  - **Clean a nerve**—to use a probe (or scissors technique) to strip the connective tissue around the nerve for purposes of observing its relationships and branches.
  - **Clean a vessel**—to use a probe (or scissors technique) to strip the fat and connective tissue off the surface of a vessel, or its branches, to illustrate its relationships.
- **Define**—to use blunt dissection to enhance a structure to better illustrate its relationships. Defining a structure usually involves bluntly dissecting the loose connective tissue away from it.
- **Retract**—to pull a structure to one side to visualize another structure that lies more deeply. Retraction is a temporary displacement and is not intended to harm the retracted structure.
- **Transect**—to cut a structure in two in the transverse plane, as in transection of a muscle belly or tendon.
- **Reflect**—to fold back from a cut edge, as in folding back a transected muscle to view what is beneath it. The reflected tissue should remain attached to the specimen.

- **Strip a vein**—to remove a vein and its tributaries from the dissection field so that the artery and related structures can be seen more clearly. Veins are stripped either by blunt dissection using a probe or carefully with scissors using a combination of blunt and sharp dissection techniques.

## ANATOMICAL POSITION

Anatomists describe the position and relation of structures of the body relative to the *anatomical position* as illustrated in FIGURE I.3. In the anatomical position, the person stands erect with the face and feet directed forward and arms by the sides with palms facing forward. During dissection, structures are described as though the body was in the anatomical position, even though the cadaver is lying on a dissection table either **supine** (face up) or **prone** (face down). When encountering a structure during dissection, be aware of its position, its relationship to other structures, its size and shape, its function, its blood supply, and its nerve supply. Learn to give an accurate account of each important structure in an orderly and logical fashion by describing it to your lab partners. Always base your descriptions on the anatomical position.

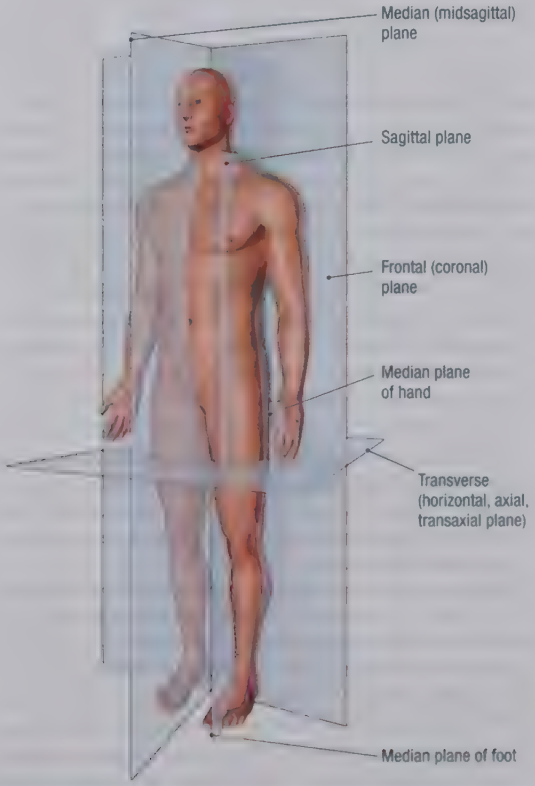


FIGURE I.3 ■ Anatomical position and anatomical planes. Anterolateral view.

## ANATOMICAL PLANES

With the body in anatomical position, anatomists describe three planes that intersect the body as points of reference for either structure location or movement (FIG. I.3). With the exception of the **median (midsagittal) plane**, the anatomical planes may be found at any level parallel to the original point of reference. A clear understanding of anatomical planes will assist your understanding of cross-sectional anatomy and diagnostic imaging. The cross-sectional images seen in this dissection guide represent axial views of various body regions as viewed from inferior to superior.

- **Sagittal planes** course vertically through the body and divide the body into right and left halves. Often, sagittal planes are given a specific point of reference to assist physicians in identification of structures correlating to that point, such as a sagittal plane passing midway through the clavicle.
    - **Median plane (midsagittal plane)** is the sagittal plane that lies in the midline of the body cutting vertically through the axis to divide the body into "equal" right and left halves. **Medial** is a term used to describe structures closer to the median plane, and **lateral** is a term used to describe structures further from the median plane.
- **Frontal (coronal) planes** course vertically through the body at a right angle to the median plane and divide the body into **anterior/ventral** (the portion of the body in front of the plane) and **posterior/dorsal** (the portion of the body behind the plane) parts.
- **Transverse (horizontal, axial, transaxial) planes** course horizontally through the body at right angles to both the frontal and sagittal planes and divide the body into **superior** (the portion of the body above the plane) and **inferior** (the portion of the body below the plane) parts.

It is important to note that the hands and feet have their own unique median planes to reference movement of the digits. The median plane of the hand runs through the third metacarpal, whereas the median plane of the foot runs through the second metatarsal.

## ANATOMICAL VARIATION

All bodies have the same basic architectural plan, but just as no two bodies are identical on the outside, it should be no surprise that no two bodies are identical on the inside. Minor variations, such as variation in size, color, and pathway of a vessel, commonly occur in all regions of the body and should be expected. At the onset of dissection, the focus should be on learning normal (average) anatomy rather than the variation unless specifically instructed to do otherwise. Take time during each dissection period to view several dissections on neighboring cadavers so that you can learn to appreciate anatomical variations and be better prepared for identification examinations.

Before beginning to dissect, consult your textbook for additional **terms of relationship and comparison, terms of laterality**, and **terms of movement**. These terms form an important part of the language of anatomy, and it is not possible to understand anatomical descriptions without understanding and using these terms.

## DAILY DISSECTION ROUTINE

To get the most out of dissection, it is recommended that you establish a routine approach to each day's dissection, such as the following:

- **Prepare before the lab**. Read the dissection assignment in this book and become familiar with the new vocabulary, the structures to be dissected, and the dissection approach. When actively dissecting, you must deliberately search for structures, and a small amount of advance preparation will make the exercise go more quickly and be much more productive.
- **Watch the corresponding *Grant's Dissection Videos*** either before or during lab to gain a better visual perspective of the techniques and steps to be used in the dissection. Throughout the text, you will see the term VIDEO beneath the corresponding dissection heading with the associated video and sequence numbers listed to facilitate your search of the appropriate dissection demonstration footage.
- ***Grant's Atlas of Anatomy*** is the recommended atlas to use in the dissection lab, although alternative atlases may be similarly implemented. Corresponding page numbers have been provided to the 15th edition of *Grant's Atlas of Anatomy* to help you quickly find illustrations that support the dissection protocol as outlined.
- **Palpate bony landmarks** as indicated in the skeletal and surface anatomy sequences and use them in the search for soft tissue structures.
- **Remove fat, connective tissue, and smaller veins** to make the details of the more important structures more obvious.
- **Review the completed dissection** at the end of the dissection period and again at the start of the next dissection period. To help you do this, review exercises are included at strategic points in each chapter.
- **Complete each dissection before proceeding to the next** because the majority of the dissections will be an extension of the previous dissection.

## LAB SAFETY

Follow your laboratories guidelines, which may include the following:

- **Scrubs, white coats, or aprons** should be worn while in the laboratory. For sanitary reasons, this outer layer of clothing should not be worn outside of the dissection laboratory, and scrubs should immediately be changed upon exiting the lab.
- **Do not wear sandals or open-toed shoes in the laboratory** because a dropped scalpel, dissection instrument, or other piece of lab equipment can seriously injure your foot.
- **Nitrile or latex gloves** must be worn to prevent contact with human tissue and fixatives.
- **Wear eye protection** such as goggles or glasses when using a bone saw to protect your eyes from potential projectiles.

## REMOVING THE SKIN

Removal of the skin is a key component of the dissection protocol and often sets the tone of the entire dissection. Prior to commencing a new region of study, the decision to either reflect or remove the skin must be made. As part of your consideration for which set of instructions to follow, it should be noted that the skin is impermeable to water; hence, an advantage of leaving a portion of the skin and fat connected to the cadaveric specimen is increased "working time" by preventing desiccation. In all skinning methods, care must be taken to accurately remove the skin without damaging the underlying structures. For each sequence of dissection instructions related to skin incisions, the following approaches may be applied:

- **Skin reflection** will require that the majority of the sequential cuts be made initially; however, a portion of skin will be left uncut, typically along the periphery of the region, to have a plane of reflection leaving a section of the skin attached to the underlying tissue. The plane of connected tissue will be used as a "hinge" to move the section of skin out of the way while performing the dissection sequence and then to replace it back to anatomical position to prevent desiccation of the exposed structures.
- **Skin removal** will require that all the sequential cuts be made to completely remove the entire region of skin from the dissection field. Fully removing the skin will allow full exposure of the underlying structures; however, more care must be taken to prevent desiccation of the exposed structures. It is possible to simply overlay the entire piece of removed skin back on the body in a full removal method to prevent desiccation similar to the reflection approach.

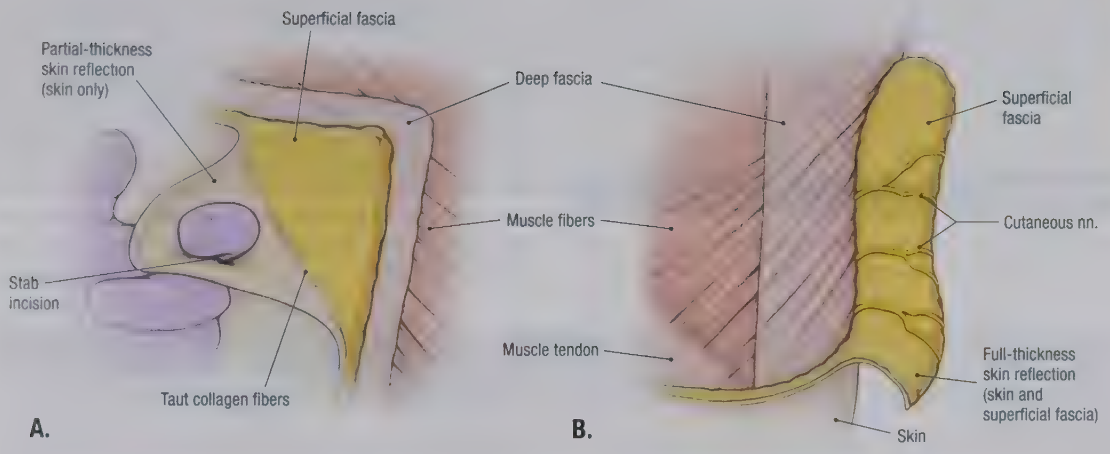


FIGURE I.4 ● **A.** Buttonhole technique in partial-thickness skin reflection. **B.** Full-thickness skin reflection.

In addition to determining if the skin should be removed or reflected, it should be noted that skin removal may be completed using either of the following approaches:

- **A partial-thickness** method removes the dermis and epidermis only, leaving the superficial fascia intact to better identify and isolate superficial veins and cutaneous nerves as demonstrated in FIGURE I.4A. A partial-thickness technique offers the advantage of increased visibility of some structures; however, it does require more time, a potentially limiting consideration for some dissection courses.
- **A full-thickness** method describes removal of the dermis, epidermis, and underlying subcutaneous tissue together in a deeper block simultaneously as demonstrated in FIGURE I.4B. For shorter courses with less space in the lab, full removal of skin may be preferred as the working space remains "cleaner" with less oil, fat, and fluids from the embalming process on the dissection table, which may continue to release from the subcutaneous tissue during your dissection.

Often, a mixed approach to partial- and full-thickness removal is optimal to offer an accelerated pace in some body regions while allowing for more care and caution in others. For the provided dissection instructions in this text, all sections related to skin removal are assumed to be partial thickness, and all those described as skin reflection are assumed as full thickness.

A variable amount of subcutaneous tissue (also called superficial fascia) lies immediately deep to the skin. The subcutaneous tissue contains fat, cutaneous nerves, and superficial blood vessels. The thickness of skin varies from region to region. For example, the skin is relatively thin on the dorsum of the hand and is considerably thicker over palm of the hand. Generally, skin incisions should not extend into the subcutaneous tissue; therefore, a general understanding of regional skin thickness is important.

To begin skinning, make incision lines of the appropriate depth, either full or partial, along the recommended incision lines as instructed in this manual. Following the initial incision, use toothed forceps or hemostats to grasp the skin at the intersection of two incision lines. Once a skin flap has been raised, place traction on the skin as it is being removed and direct the scalpel blade toward the deep surface of the skin to cut the underlying taut collagen fibers. Avoid directing the scalpel toward the body because the blade will readily cut through and destroy underlying subcutaneous tissue, muscle, and neurovascular structures. To steady your scalpel hand, rest it against the cadaver and hold the scalpel as you would hold a pencil and make short (5 to 10 cm) sweeping motions as demonstrated in FIGURE I.5. To prevent

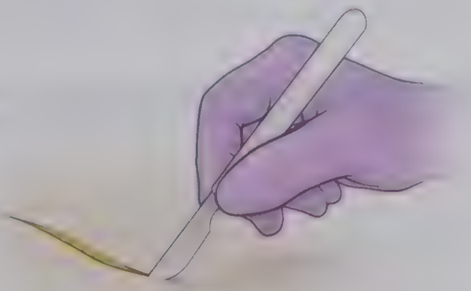


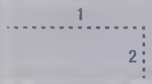
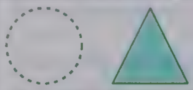
FIGURE I.5 ● Scalpel dissection technique with hand resting on body surface for stability.

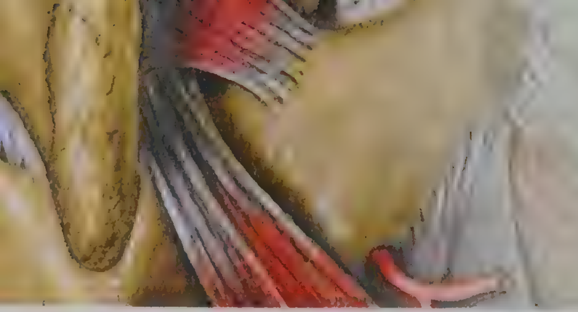
accidents, do not work too close to your lab partners and always hold the skin with dissection instruments and not your fingers when making new incisions with a scalpel.

## FIGURES

Throughout the various dissection chapters, you will see a large number of illustrative figures meant to assist you in your dissection efforts. In each region, the provided figures will guide you from the initial skin removal through the various tissue layers to the underlying organs or joints. As many of the instructional steps will be similar in nature, a standardized labeling scheme has been implemented in the figures with the following line and abbreviation features. Take a moment to review **TABLE I.1** of commonly used figure abbreviations and lines prior to beginning your dissection protocols, and refer back to this table as needed throughout the course of your dissection.

**TABLE I.1** **Commonly Used Figure Abbreviations and Lines**

| *Anatomical Structure or Reference* | *Abbreviation or Figure Element* |
|---|---|
| Artery and arteries | a. and aa. |
| Vein and veins | v. and vv. |
| Nerve and nerves | n. and nn. |
| Muscle and muscles | m. and mm. |
| Cranial nerve | CN (followed by roman numeral) |
| Point of reference line(s) | ···················· |
| Incision line(s) and sequence |  1<br>2 |
| Optional incision or reflection line(s) | -------------------- |
| Previously made incision line(s) | ———————— |
| Boundary or border line(s) |  |



CHAPTER 1

# The Back

**REFERENCES**

ATLAS = *Grant's Atlas of Anatomy*, 15th ed., figure number

VIDEO = *Grant's Dissection Videos*, video sequence number

The back is the posterior aspect of the trunk extending from the base of the skull to the tip of the coccyx. The back plays important roles in posture, upper limb stability and movement, and protection of visceral and neurovascular structures. The back consists of skin, subcutaneous tissue, fascia and connective tissue, three layers of skeletal muscle, the vertebral column, the spinal cord and meninges, and segmentally located neurovascular structures.

The vertebral column consists of 33 vertebrae: 7 cervical (C), 12 thoracic (T), 5 lumbar (L), 5 sacral (S), and 4 coccygeal (Co). The vertebrae are numbered within each region from superior to inferior. The upper 24 vertebrae (cervical, thoracic, and lumbar) allow flexibility and movement of the vertebral column. The lower vertebrae (sacral and coccygeal) are fused to provide rigid support of the pelvic girdle and to transmit forces to and from the lower limb.

**CLINICAL CORRELATIONS**

During the course of your dissection protocol, you may encounter anatomical variations, clinical conditions, disease processes, or medical devices in your cadaveric donor. The following select clinical correlations will be described in more detail throughout this chapter.

**The Back**

1. Excessive Vertebral Curvature (Kyphosis, Lordosis, and Scoliosis), see the **Thoracic Vertebrae** sequence. ATLAS 1.1A, 1.2A, 1.2C
2. Herniated Disc, see the **Cervical and Lumbar Vertebrae** sequence. ATLAS 1.16
3. Triangles of the Back, see the **Rhomboid Major and Rhomboid Minor Muscles** sequence. ATLAS 1.26, 1.27, 2.30
4. Lumbar Puncture and Epidural Anesthesia, see the **Laminectomy** sequence. ATLAS 1.38
5. Vertebral Venous Plexuses, see the **Spinal Meninges** sequence. ATLAS 1.44A, 1.44B

## SKIN AND SUPERFICIAL FASCIA OF THE BACK

### Dissection Overview

The skin of the back, the underlying subcutaneous tissue, and the deep muscles of the back receive innervation segmentally from the dorsal (posterior) primary rami. The majority of the dorsal primary rami are unnamed and referred to by their corresponding vertebral levels with the exception of the suboccipital nerve (C1), the greater occipital nerve (C2), and the cluneal nerves in the gluteal region.

The order of dissection will be as follows: The skeletal anatomy of the vertebral column and the surface anatomy of the back will be studied. The skin will be either reflected or removed from the back, the posterior surface of the neck, and the posterior surface of the proximal upper limb. The subcutaneous tissue will either be removed or reflected in a full- or partial-thickness approach. Neurovascular structures in the occipital region will be studied.

## Skeletal Anatomy

Refer to an articulated skeleton or individual bones and identify the following skeletal features.

### *Vertebral Column and Scapula*

ATLAS 1.3, 2.3

1. Refer to FIGURE 1.1.
2. On the **occipital bone**, identify the **external occipital protuberance**.
3. Identify the **superior nuchal line** arching laterally from the external occipital protuberance and observe that it runs parallel to the more inferiorly located **inferior nuchal line**.
4. On the **temporal bone**, identify the large **mastoid process** inferolaterally, posterior to the **external acoustic meatus**.
5. Identify the spinous process (spine) of a cervical vertebra and observe that they are often "split" or **bifid**.
6. Identify the C7 vertebra and observe that it has the most prominent spinous process in the cervical region, the **vertebra prominens**, which unlike the other spinous processes in the cervical region is typically not bifid.

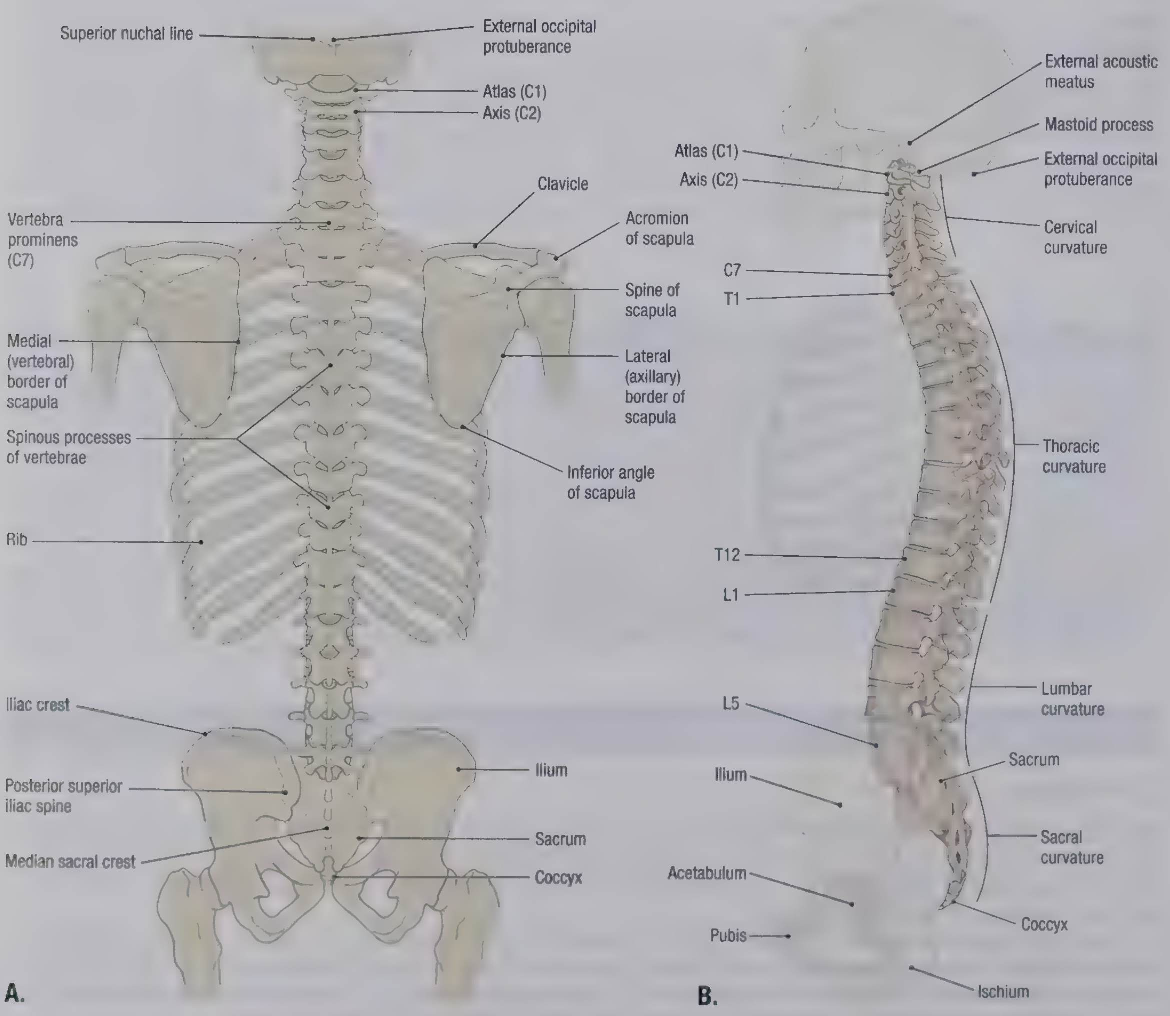

Superior nuchal line
External occipital protuberance
Atlas (C1)
Axis (C2)
Clavicle
Vertebra prominens (C7)
Acromion of scapula
Spine of scapula
Medial (vertebral) border of scapula
Lateral (axillary) border of scapula
Spinous processes of vertebrae
Inferior angle of scapula
Rib
Iliac crest
Ilium
Posterior superior iliac spine
Sacrum
Median sacral crest
Coccyx
A.
External acoustic meatus
Mastoid process
Atlas (C1)
Axis (C2)
External occipital protuberance
Cervical curvature
C7
T1
Thoracic curvature
T12
L1
L5
Lumbar curvature
Sacrum
Ilium
Sacral curvature
Acetabulum
Coccyx
Pubis
Ischium
B.

FIGURE 1.1 ■ Skeleton of the back. A. Posterior view. B. Lateral view.

7. Identify the spinous process of a thoracic vertebra and observe that it is relatively long and slender and is directed inferiorly and posteriorly to overlap the adjacent spinous process of the vertebra inferior to it.
8. Identify the spinous process of a lumbar vertebra and observe that it is broad and blunt and does not overlap with the adjacent vertebrae.
9. On the **scapula**, identify the **spine of the scapula**, the large ridge along its posterior surface.
10. Follow the spine of the scapula laterally and identify the **acromion process**, the most lateral portion of the bone.
11. Observe that the scapula is roughly triangular in shape with the **superior angle**, the acromion process, and the **inferior angle** forming the points of the triangle, and the **medial (vertebral) border** and **lateral (axillary) border** forming the lower two sides of the triangle.

### *Thoracic Vertebrae*

ATLAS 1.12

1. Refer to FIGURE 1.2.
2. On a **thoracic vertebra**, identify the large bony mass of the **vertebral body**.
3. Identify the pedicles, the short bony processes arching posteriorly from the vertebral body bilaterally.
4. Identify the **transverse processes** and associated **transverse costal facets**.
5. Observe that articulation with ribs is a unique characteristic of thoracic vertebrae. On an articulated skeleton, verify that the head of ribs 1, 10, 11, and 12 articulate with the body of one vertebra, while the remaining ribs articulate with the **demifacets**, the **superior** and **inferior costal facets**, of two adjacent vertebrae and the associated **intervertebral (IV) disc**.
6. Observe that the tubercle of a rib articulates with the transverse costal facet of the thoracic vertebra of the same number (i.e., the tubercle of rib 5 articulates with the transverse costal facet of vertebra T5).
7. Identify the **superior** and **inferior articular processes** with their associated **facets (surfaces)**. *Note that in the thoracic region, the articular facets are orientated coronally, thus allowing for lateral flexion and rotation while limiting flexion and extension anteriorly and posteriorly.*
8. Identify an **inferior vertebral notch** of one vertebra and the **superior vertebral notch** of the vertebra immediately inferior and observe how together they form an **IV foramen**. *Note that a spinal nerve passes through the IV foramen from the vertebral canal where it arose from the spinal cord.*

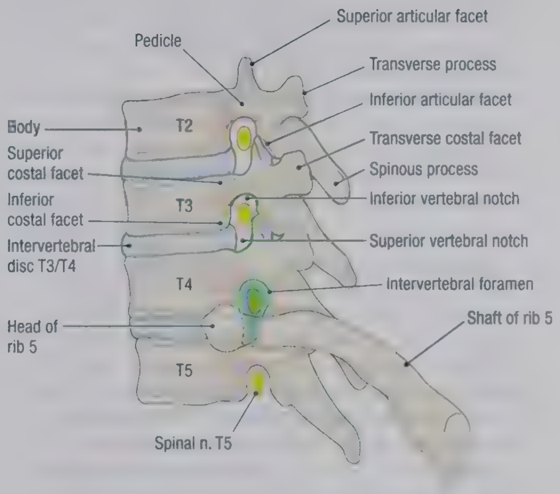


FIGURE 1.2 ● Thoracic vertebrae. Lateral view.

## CLINICAL CORRELATION

### Excessive Vertebral Curvature (Kyphosis, Lordosis, and Scoliosis)

ATLAS 1.1A, 1.2A, 1.2C

Congenital abnormalities, degenerative diseases, or other pathologic processes such as osteoporosis can lead to excessive vertebral curvature. Kyphosis is an exaggeration of thoracic curvature, often caused by degeneration of the anterior aspect of the vertebral bodies. Lordosis is an exaggeration of the lumbar curvature, often due to rotation of the hips caused by weakened trunk muscles. Scoliosis is an abnormal amount of lateral curvature of the vertebral column, often accompanied by rotation of the vertebrae and ribs due to muscular weakness or developmental anomalies.

## Cervical and Lumbar Vertebrae

ATLAS 1.7, 1.13

1. Refer to FIGURE 1.3.
2. On a set of disarticulated **cervical vertebrae**, observe that they differ from thoracic vertebrae because they have smaller vertebral bodies, larger vertebral foramina, and shorter spinous processes that often bifurcate at the tip and that they do not have transverse costal facets for rib attachment.
3. Identify a transverse process and associated **transverse foramen (foramen transversarium)**. *Note that the transverse foramina of the cervical vertebrae, with the exception of the C7 foramina, allow for passage of the vertebral arteries bilaterally.*
4. Identify the **superior** and **inferior articular processes** of a cervical vertebra with the associated **superior** and **inferior articular facets**, respectively. *Note that in the cervical region, the articular facets are orientated more horizontally, allowing for increased rotational movement while maintaining large degrees of flexion and extension.*
5. Refer to a set of disarticulated **lumbar vertebrae** and observe that they differ from thoracic vertebrae because they have larger vertebral bodies, broad spinous processes that project posteriorly, and no transverse costal facets for rib attachment.
6. From a superior view, identify the **vertebral arch**, which is formed by the bilateral **pedicles** and **laminae** and encloses the **vertebral foramen** with the posterior aspect of the vertebral body.
7. Identify the large **superior** and **inferior articular processes** of a lumbar vertebra with the associated **superior** and **inferior articular facets**, respectively. *Note that in the lumbar region, the articular facets are orientated more sagittally, allowing for increased flexion and extension anteriorly and posteriorly with limited rotation or lateral flexion.*

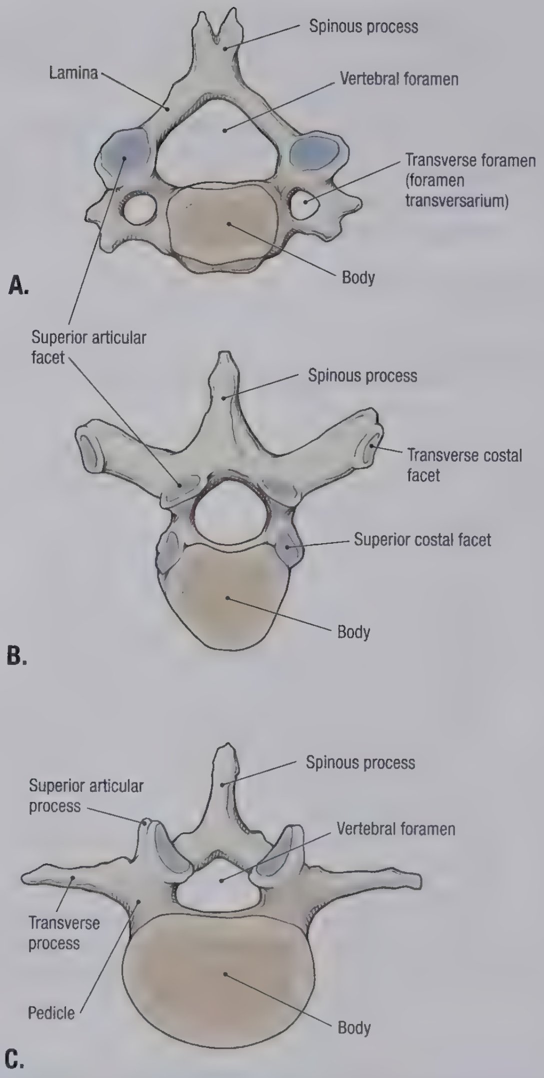


FIGURE 1.3 ■ **A.** Cervical (C4) vertebra. **B.** Thoracic (T6) vertebra. **C.** Lumbar (L4) vertebra. Superior views.

### CLINICAL CORRELATION

**Herniated Disc**

ATLAS 1.16

Intervertebral discs are composed of an outer anulus fibrosus, a series of concentric rings of tough fibrocartilage, and an inner nucleus pulposus, a gelatinous mass assisting in shock absorption. A herniation occurs when the inner nucleus pulposus pushes, or extrudes, into or through the outer anulus fibrosus into the surrounding space. The herniation of the nucleus pulposus commonly occurs posterolaterally to the side of the posterior longitudinal ligament into the vertebral canal or an IV foramen. Herniation may lead to spinal cord or spinal nerve compression resulting in sensory and/or motor deficits, along with possible pain in the region supplied by the compressed nervous structure. Herniation may occur following a traumatic injury or evolve over time as seen with bone degeneration or poor posture.

### *Sacrum and Ilium*

ATLAS 1.19B, 1.20B

1. Refer to FIGURE 1.4.
2. Identify the **sacrum** and observe that it is formed by five fused vertebrae and does not have individual spinous or transverse processes.
3. On the posterior surface of the sacrum, identify the **median sacral crest**, the fused rudimentary spinous processes of the upper three or four sacral vertebrae.
4. Identify the **anterior** and **posterior sacral foramina**, which allow the anterior and posterior rami of sacral spinal nerves to exit from the vertebral canal anteriorly and posteriorly as the sacrum articulates on its lateral surfaces with the ilia of the hip bones.
5. On the posterior inferior aspect of the sacrum, identify the **sacral hiatus**, the inferior opening at the termination of the vertebral canal where the laminae of the fourth and fifth sacral vertebrae fail to meet.
6. Inferior to the sacrum, identify the **coccyx**, a small triangular bone formed by the fusion of four rudimentary coccygeal vertebrae.
7. Observe that the coccygeal vertebrae lack the features of typical vertebrae with the exception of the vertebral bodies.
8. Refer back to FIGURE 1.1.
9. Identify the **hip bone**, otherwise known as the **os coxae** or **innominate bones**. In the adult, the hip bone is a fusion of three separate bones that join at the **acetabulum**, the socket of the ball and the socket joint of the hip.
10. Identify the three bones of the hip: the **ilium**, the superior most bone; the **ischium**, the inferior most bone; and the **pubis**, the bone directed anteriorly toward the opposite hip bone at the midline.
11. On the **ilium**, identify the **iliac crest**, the large bony ridge extending along the superior aspect of the bone from the **anterior superior iliac spine (ASIS)** to the **posterior superior iliac spine (PSIS)**.

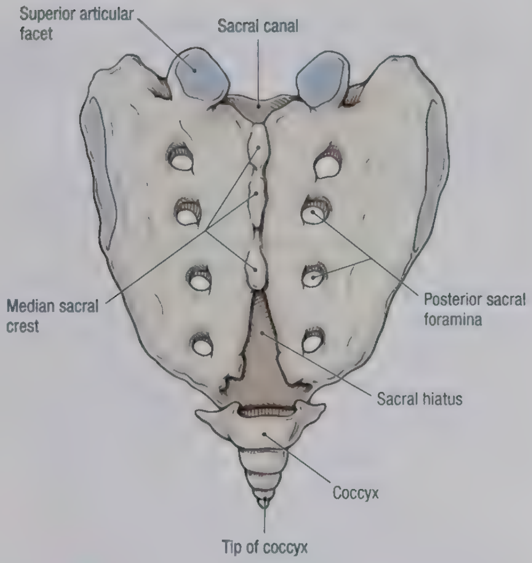


FIGURE 1.4 ● Sacrum and coccyx. Posterior view.

## Surface Anatomy

The surface anatomy of the back may be studied on a living subject or on a cadaver. On the cadaver, fixation of tissue during embalming may make it difficult to distinguish bone from well-preserved soft tissues in some specimens.

### *The Back*

ATLAS 1.25

1. Refer to FIGURE 1.5.
2. With the cadaver in the prone position (face down), palpate the **external occipital protuberance** on the posterior aspect of the head.
3. Posterior to the external ear, palpate the **mastoid process** at the base of the skull, along with the superior attachment of the sternocleidomastoid muscle, a large muscle in the anterior lateral aspect of the neck.
4. Move inferiorly along the posterior midline and make attempts to palpate the **cervical spinous processes**. Depending on body type and varying amounts of spinal curvature, the cervical spinous processes may be difficult to palpate, with the exception of the spinous process of the **vertebra prominens** (C7) at the base of the neck.
5. Beginning at the vertebra prominens, palpate laterally to identify the **superior border of the trapezius muscle** and follow it inferolaterally toward its attachment to the **acromion process of the scapula** and **lateral (acromial) end of the clavicle**.
6. Palpate from the acromion process posteriorly and medially along the **spine of the scapula** toward the **medial (vertebral) border of the scapula**. *Note that the medial aspect of the spine of the scapula is approximately at the T3 vertebral level.*
7. Follow the medial border of the scapula inferiorly toward the **inferior angle of the scapula** near vertebral level T7.
8. In the thoracic midline, palpate the **spinous processes of the thoracic vertebrae**.

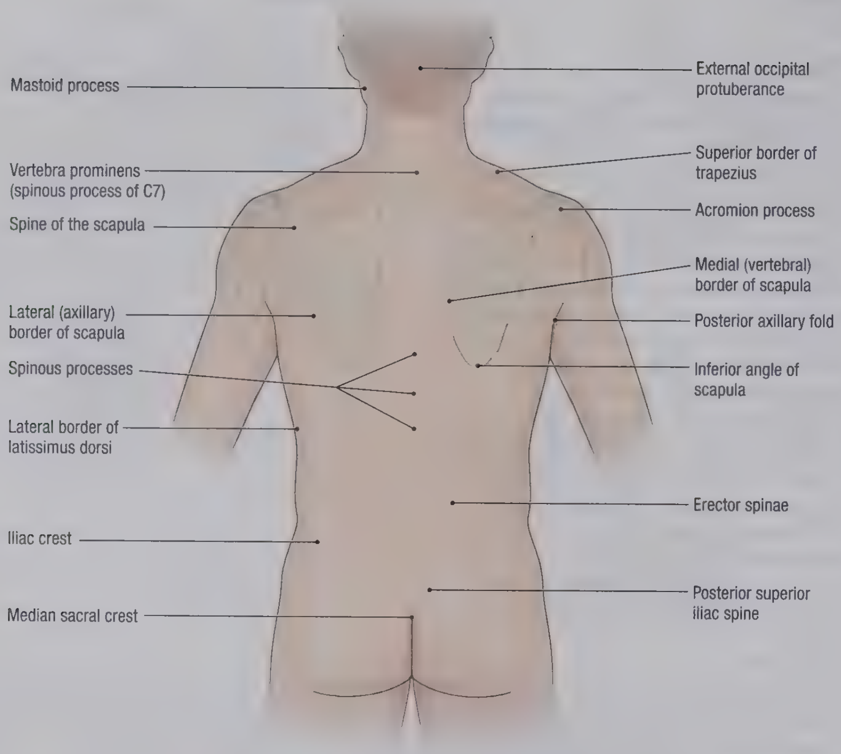

Mastoid process
External occipital protuberance
Vertebra prominens (spinous process of C7)
Superior border of trapezius
Spine of the scapula
Acromion process
Medial (vertebral) border of scapula
Lateral (axillary) border of scapula
Posterior axillary fold
Spinous processes
Inferior angle of scapula
Lateral border of latissimus dorsi
Erector spinae
Iliac crest
Posterior superior iliac spine
Median sacral crest

FIGURE 1.5 ■ Surface anatomy of the back. Posterior view.

9. Progress inferiorly with your palpation to the lumbar region and identify the bilateral masses of the **erector spinae muscle** to either side of the vertebral column.
10. Palpate along the lateral margin of the erector spinae inferiorly and identify the **iliac crest**. Observe that the superior extent of the iliac crest is at the L4 vertebral level.
11. Follow the iliac crest posteriorly and medially and identify the **PSIS**. Observe that the PSIS is approximately at the L2 vertebral level along the **median sacral crest** of the sacrum.
12. Palpate laterally along the iliac crest toward the lateral aspect of the trunk and identify the **lateral border of the latissimus dorsi muscle**.
13. Follow the lateral border of the latissimus dorsi superiorly to the axilla and observe that it forms the **posterior axillary fold**.

## Dissection Instructions

### Skin Incisions of the Back

VIDEO 1.1.1

***Dissection Note:*** Prior to commencing with skin incisions, decide to perform either a full- or partial-thickness approach and to either reflect or remove the skin from the dissection field. See **Removing the Skin** in the **Introduction Chapter** for descriptions.

1. Refer to FIGURE 1.6.
2. Use a scalpel to make a skin incision in the midline from the external occipital protuberance (X) to the tip of the coccyx (S). *Note that the skin is approximately 6 mm thick in this region, and thus, only the edge of the scalpel blade needs to penetrate the surface of the skin.*
3. To verify the thickness of the skin, make an initial small incision along the midline, and use forceps or hemostats to pull the sides apart to observe the cut

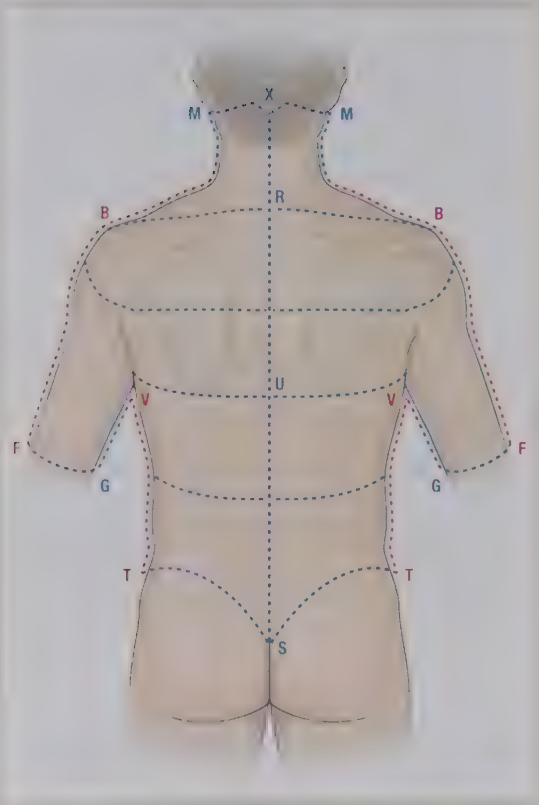


FIGURE 1.6 ● Skin incisions of the back. Posterior view.

edge of skin. In an appropriately deep skin incision, you should see underlying adipose tissue but no muscle tissue.

4. Make an incision from the inferior aspect of the median sacral crest (S) arching superiorly and laterally to the midaxillary line (T) approximating the curve of the iliac crests.
5. Make a shallow transverse skin incision from the external occipital protuberance (X) to the mastoid process (M) laterally. Care must be taken in the occipital region in either full- or partial-thickness techniques, as important neurovascular structures course within this region and should not be cut.
6. Make a transverse skin incision superior to the scapula from the midline (R) to the acromion process (B).
7. At the level of the inferior angle of the scapula, make a transverse skin incision from the midline (U) to the midaxillary line (V).
8. To facilitate skinning, make several parallel transverse incisions about 8 cm above and below the horizontal incisions described in steps 6 and 7.
9. Make a vertical incision on the inner aspect of the upper limb from the axilla to a point halfway down the arm (G).
10. Beginning on the medial aspect of the arm (G), make a shallow incision around the posterior surface of the arm toward the lateral aspect of the limb (F).

***Dissection Note:*** If reflecting the skin, skip steps 11 through 13.

11. Make a superficial skin incision down the lateral surface of the neck beginning at the mastoid process (M) along the superior border of the trapezius muscle to its attachment at the acromion process (B).
12. Continue the incision along the lateral aspect of the shoulder from the acromion process (B) to the midpoint of the arm laterally (F), connecting it with the horizontal incision made approximately halfway down the arm.
13. Make a vertical skin incision along the lateral surface of the trunk from the axilla (V) to point along the midaxillary line at the hip inferiorly (T).
14. Beginning in the middle of the back, reflect the skin from medial to lateral using either a pair of locking forceps or the buttonhole technique. At any point, the portions of skin may be cut into smaller segments to facilitate removal. *Note that even if a full-thickness reflection is desired, it may prove beneficial to begin with a partial-thickness approach until an appropriate depth of reflection is verified based on visualization of the underlying deep fascia covering the muscles.*
15. In the occipital region, make an effort to stay as superficial as possible to avoid damaging the underlying neurovascular structures in either a full- or partial-thickness approach.
16. In the posterior neck, reflect or remove the superficial fascia only as far laterally as the superior border of the trapezius muscle and do not cut into the deep fascia as nerves coursing superficially in the region are in danger of being cut.
17. If reflecting the skin, utilize the uncut sections of skin laterally as hinge points to leave the skin attached along the peripheral aspect of the back.
18. If removing the skin, once the lateral incision points are reached, detach the skin and place it in the tissue container.

## Superficial Fascia of the Back

VIDEO 1.1.2

1. Refer to FIGURE 1.7.
2. In the superficial fascia at the base of the skull, locate the **occipital artery** and the **greater occipital nerve (C2)**. *Note that the superficial veins in the region may serve as guides to identify the location of the occipital artery but care need not be taken to preserve them.*

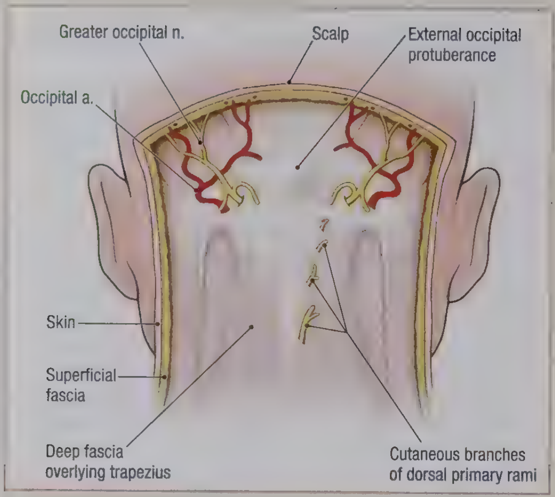

Greater occipital n.
Scalp
External occipital protuberance
Occipital a.
Skin
Superficial fascia
Deep fascia overlying trapezius
Cutaneous branches of dorsal primary rami

**FIGURE 1.7** ■ Superficial dissection of the occipital region. Posterior view.

3. Observe that the greater occipital nerve pierces the **trapezius muscle** about 3 cm inferolateral to the **external occipital protuberance.**
4. Observe that the greater occipital nerve often crosses the occipital artery along its path to the skin on the posterior aspect of the head.
5. Use blunt dissection to isolate the greater occipital nerve, the posterior (dorsal) ramus of spinal nerve C2. *Note that the deep fascia in this area is very dense and tough and it may be difficult to find the greater occipital nerve.*
6. Observe that the **cutaneous branches of the dorsal primary rami** pierce the trapezius muscle in the posterior aspect of the neck to enter the superficial fascia. To save time, make no deliberate effort to display posterior cutaneous branches of the posterior rami.
7. Reflect the superficial fascia of the back by cutting it along similar lines to the skin incision lines. Work from medial to lateral to detach the superficial fascia and place it in the tissue container. *Note that if a full-thickness skin reflection or removal has been implemented, this process has already been performed.*

## Dissection Follow-up

1. Review the key anatomical landmarks for the surface anatomy of the back.
2. Review the anatomical features of the cervical, thoracic, and lumbar vertebrae noting the respective similarities and differences.
3. Review the pattern of innervation of posterior (dorsal) rami including the greater occipital nerve (C2).
4. Study a dermatome chart and become familiar with the concept of segmental innervation.
5. If a full- or partial-thickness skin reflection was performed, replace the reflected portions of skin back to anatomical position.

# SUPERFICIAL MUSCLES OF THE BACK

## Dissection Overview

The back contains three groups of muscles: the superficial muscles of the back, the intermediate muscles of the back, and the deep muscles of the back. The muscles in all three muscle groups attach to the vertebral column, which forms the axis of the trunk, supports the weight of the body, transmits forces generated by movement, and provides a protective bony covering for the spinal cord and nerve roots.

The superficial muscles of the back are trapezius, latissimus dorsi, rhomboid major, rhomboid minor, and levator scapulae. Unlike the skin of the back and the deep muscle layer, the superficial muscles of the back are innervated by the ventral primary rami and serve to affect movement and stability of the upper limb through attachment to the scapula.

The order of dissection will be as follows: The superficial surface and borders of the trapezius muscle will be cleaned. The trapezius muscle will be examined and reflected. The latissimus dorsi muscle will be cleaned, studied, and reflected. The rhomboid major muscle, rhomboid minor muscle, and levator scapulae muscle will be identified. Dissection of the superficial back muscles should be performed bilaterally.

## Dissection Instructions

***Dissection Note:*** If available, place a block under the shoulder to facilitate dissection of the superficial muscles of the back by relieving tension in the region. Perform the following dissection instructions bilaterally.

### Trapezius Muscle

ATLAS 1.26; VIDEO 1.2.1

1. Refer to FIGURE 1.8.
2. Clean the fat and connective tissue from the posterior surface of the **trapezius muscle**, the large diamond-shaped superficial muscle of the back. Clearly define the inferolateral border of the trapezius muscle but do not disturb its superolateral border at this time.
3. Review the attachments and actions of the trapezius muscle (see **TABLE 1.1**).
4. Prepare the trapezius muscle for reflection by using blunt dissection deep to the inferolateral border of the muscle (medial to the inferior angle of the scapula) and progress superiorly as far as possible by gently tearing the connective tissue between the trapezius and the deeper muscles of the back. *Note that it is important to use caution while breaking the fascial connections deep to the trapezius muscle as the muscle can easily be torn with excessive force.*
5. Use sharp dissection to detach the trapezius muscle from the spinous processes inferiorly and extend the cut superiorly to the level of the nuchal ligament and external occipital protuberance (**Cut 1**).
6. Make a short transverse cut (2.5 cm) across the superior end of the trapezius muscle to detach it from the superior nuchal line while sparing the greater occipital nerve and the occipital artery (**Cut 2**). Do not extend the transverse cut beyond the superolateral border of the trapezius muscle.
7. Cut the trapezius muscle as close as possible from its lateral attachments on the superior aspect of the spine and acromion of the scapula (**Cut 3**).
8. Leave the trapezius muscle attached to the clavicle and the cervical fascia and carefully reflect the muscle superolaterally.
9. On the deep surface of the reflected trapezius muscle, identify the plexus of nerves formed by the **spinal accessory nerve (CN XI)**, providing motor innervation, and **branches of the anterior (ventral) rami of spinal nerves C3** and **C4**, providing proprioception. *Note that at this point in the dissection, it may not be possible to distinguish which portion of the plexus arises from which source.*
10. Observe that the **superficial branch of the transverse cervical artery**, along with its corresponding veins, accompanies the plexus of nerves on the deep surface of the trapezius muscle.
11. Remove the transverse cervical veins to clear the dissection field.
12. Observe that superiorly the spinal accessory nerve passes through the posterior triangle of the neck. Do not make attempts to follow the nerve into the posterior triangle at this time as it will be dissected further in the neck dissections.

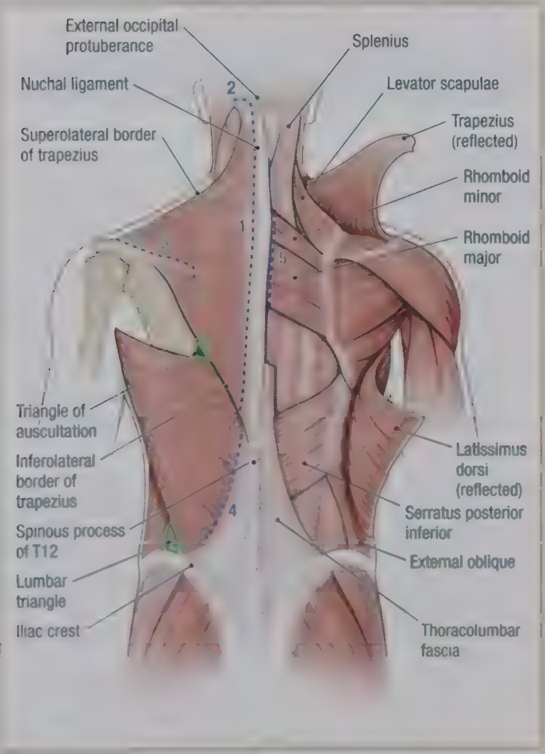

External occipital protuberance
Nuchal ligament
Superolateral border of trapezius
Triangle of auscultation
Inferolateral border of trapezius
Spinous process of T12
Lumbar triangle
Iliac crest
2
1
4
Splenius
Levator scapulae
Trapezius (reflected)
Rhomboid minor
Rhomboid major
Latissimus dorsi (reflected)
Serratus posterior inferior
External oblique
Thoracolumbar fascia

FIGURE 1.8 ● Superficial muscles of the back. Posterior view.

### Latissimus Dorsi Muscle

ATLAS 1.26; VIDEO 1.2.2

1. Refer to FIGURE 1.8.
2. Clean the surface and borders of the **latissimus dorsi muscle**, the broad flat muscle inferior to the trapezius.
3. Review the attachments and actions of the latissimus dorsi muscle (see **TABLE 1.1**).
4. The latissimus dorsi muscle receives the **thoracodorsal nerve** and **artery** on its anterior surface near its lateral attachment on the humerus. Do not make attempts to isolate the lateral attachment of the latissimus dorsi muscle, its nerve, or its artery at this time because they will be dissected with the upper limb.

5. To reflect the medial aspect of the latissimus dorsi muscle, use blunt dissection deep to the superior border of the muscle (medial to the inferior angle of the scapula) and break the plane of loose connective tissue that lies between it and the deeper muscles.
6. Elevate the latissimus dorsi muscle enough to insert scissors and cut through its medial attachment to the thoracolumbar fascia (**Cut 4**) and not along its attachment to the lumbar spinous processes because this will damage underlying structures.
7. Reflect the latissimus dorsi muscle laterally making an effort to not disturb its attachment to the ribs or the possible attachment to the inferior angle of the scapula. *Note that the serratus posterior inferior muscle, an intermediate layer of back muscle, is often inadvertently reflected with the latissimus dorsi.*

## Rhomboid Major and Rhomboid Minor Muscles

ATLAS 1.26, 1.27; VIDEO 1.2.3

1. Refer to FIGURE 1.8.
2. Medial to the scapula, clean the surface and borders of the more inferiorly located **rhomboid major muscle** and the more superiorly located **rhomboid minor muscle**.
3. Review the attachments and actions of the rhomboid major and minor muscles (see **TABLE 1.1**).
4. Use blunt dissection to separate the rhomboid muscles from one another using the lateral attachments along the scapula as a guide. Observe that the rhomboid minor muscle typically attaches at the height of the spine of the scapula, whereas the rhomboid major muscle attaches inferior to the spine along the medial (vertebral) border of the scapula.
5. To reflect the rhomboid muscles, use blunt dissection deep to the inferior border of the rhomboid major muscle and separate it from the deeper muscles.
6. Working from inferior to superior, use scissors to detach the rhomboid major muscle from its medial attachments on the spinous processes, and the rhomboid minor muscle from its medial attachments on the spinous processes and ligamentum nuchae (**Cut 5**).
7. Reflect the rhomboid major and minor muscles laterally. *Note that the serratus posterior superior muscle, an intermediate layer of back muscle, is often inadvertently reflected with the rhomboid muscles.*

### CLINICAL CORRELATION

**Triangles of the Back**

ATLAS 1.26, 1.27, 2.30

The triangle of auscultation is bound by the latissimus dorsi muscle inferiorly, the trapezius muscle superiorly, and the rhomboid major muscle and scapula laterally. The triangle of auscultation is approximately at intercostal space 6, and because it has no overlying muscles, it is particularly well suited for auscultation (listening to sounds produced by thoracic organs, particularly the lungs).

The lumbar triangle is bound by the latissimus dorsi muscle medially, the external oblique muscle laterally, and the iliac crest inferiorly. The floor of the lumbar triangle is the internal oblique muscle of the abdomen. Due to a similar gap in muscle tissue as the triangle of auscultation, on rare occasions, the lumbar triangle is the site of a lumbar hernia.

8. On the deep surface of the two rhomboid muscles, near their lateral attachments on the medial border of the scapula, use blunt dissection to find the **dorsal scapular nerve** and **dorsal scapular vessels**. *Note that the dorsal scapular artery may branch directly from the subclavian artery, or from the transverse cervical artery, in which case it is also known as the* ***deep branch of the transverse cervical artery****.*

## Levator Scapulae Muscle

ATLAS 1.27; VIDEO 1.2.4

1. Refer to FIGURE 1.8.
2. Identify the **levator scapulae muscle** superior to the rhomboid minor. *Note that at this stage of the dissection, the levator scapulae muscle can be seen only near its inferior attachment to the superior angle of the scapula.*
3. Clean the surface and borders of the levator scapulae muscle inferiorly but do not dissect its superior attachments to the transverse processes of the upper four cervical vertebrae.
4. Observe that the dorsal scapular nerve and artery supply the levator scapulae muscle prior to reaching the rhomboids and that they pass anterior (deep) to the inferior end of the muscle.
5. Review the attachments and actions of the levator scapulae muscle (see **TABLE 1.1**).

## Dissection Follow-up

1. Review the boundaries of the two triangles associated with the latissimus dorsi muscle, the triangle of auscultation and the lumbar triangle, and the clinical significance of each.
2. Review the attachments, actions, and innervations of the superficial muscles of the back in **TABLE 1.1**.
3. Review the movements that occur between the scapula and the thoracic wall.
4. Replace the superficial muscles of the back and any portion of reflected skin back to their correct anatomical positions.
5. Use an illustration to observe the origin of the transverse cervical artery and the origin of the dorsal scapular artery.

**TABLE 1.1 Superficial Muscles of the Back**

| *Muscle* | *Medial Attachments* | *Lateral Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Trapezius | Superior nuchal line, external occipital protuberance, ligamentum nuchae, SP C7–T12 | Lateral one-third of the clavicle and acromion and spine of scapula | Rotates scapula to tilt the glenoid cavity superiorly, elevates (superior part), retracts (middle part), and depresses (inferior part) scapula | Motor: spinal accessory n. (CN XI)<br>Proprioception: C3–C4 |
| Latissimus dorsi | SP T7–L5, thoracolumbar fascia, sacrum, iliac crest, ribs 10–12 | Floor of intertubercular sulcus of humerus | Extends, adducts, and medially rotates humerus | Thoracodorsal n. (middle subscapular n.) |
| Levator scapulae | TP C1–C4 | Superior angle of scapula | Elevates and rotates the scapula to tilt the glenoid cavity inferiorly | Dorsal scapular n. |
| Rhomboid major | SP T2–T5 | Medial border of scapula below spine | Retracts and rotates the scapula to tilt the glenoid cavity inferiorly | |
| Rhomboid minor | Ligamentum nuchae, SP C7–T1 | Medial border of scapula at spine | | |

Abbreviations: C, cervical vertebrae; CN, cranial nerve; L, lumbar vertebrae; n., nerve; SP, spinous process; T, thoracic vertebrae; TP, transverse process.

# INTERMEDIATE AND DEEP MUSCLES OF THE BACK

## Dissection Overview

The intermediate muscles of the back are the serratus posterior superior and the serratus posterior inferior, the thin muscles attaching to the spinous processes and ribs. The intermediate muscles of the back act as accessory muscles of respiration and are innervated by intercostal nerves.

The deep muscles of the back include the splenius capitis, splenius cervicis, the erector spinae group, and the transversospinales group. The deep muscles of the back act on the vertebral column to cause rotational and lateral bending movements between adjacent vertebrae, act to extend and stabilize the vertebral column, and are innervated by posterior rami of spinal nerves.

The order of dissection will be as follows: The deep muscles of the posterior neck (splenius capitis and cervicis) will be studied and reflected. The erector spinae muscles will be dissected and their component parts identified. The semispinalis capitis and semispinalis cervicis muscles and the multifidus muscles of the transversospinales group will be cleaned and identified.

## Dissection Instructions

***Dissection Note:*** Perform the following dissection instructions bilaterally.

### Serratus Posterior Superior Muscle

ATLAS 1.27; VIDEO 1.3.1

1. Refer to FIGURE 1.9.
2. Identify the **serratus posterior superior muscle** deep to the rhomboid muscles. *Note that if you do not see the serratus posterior superior muscle, it may be attached to the deep surface of the reflected rhomboid muscles.*
3. Clean the surface and borders of the serratus posterior superior muscle.
4. Review the attachments and actions of the serratus posterior superior muscle (see **TABLE 1.2**).
5. Use scissors to cut the medial attachments of the serratus posterior superior muscle along the nuchal ligament and the spinous processes of vertebrae C7–T3 (**Cut 1**).

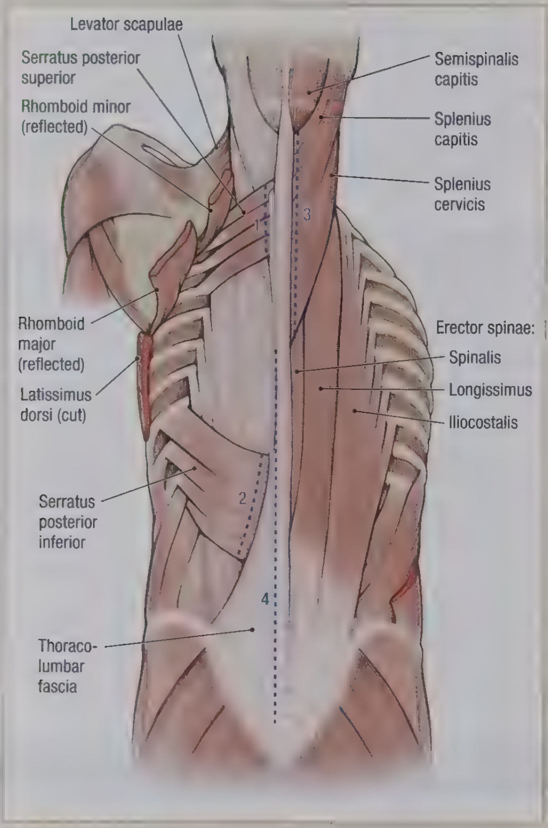


FIGURE 1.9 Intermediate (*left*) and superficial (*right*) layers of deep back muscles. Posterior view.

6. Reflect the serratus posterior superior laterally leaving its attachments intact along the superior borders of ribs 2 to 5 lateral to their angles.

## Serratus Posterior Inferior Muscle

ATLAS 1.27; VIDEO 1.3.2

1. Refer to FIGURE 1.9.
2. Identify the **serratus posterior inferior muscle** deep to the latissimus dorsi muscle. *Note that if you do not see the serratus posterior inferior muscle, it may be attached to the deep surface of the reflected latissimus dorsi muscle.*
3. Continue reflecting the latissimus dorsi muscle laterally along its attachments to the ribs to achieve greater visibility of the serratus posterior inferior muscle.
4. Clean the surface and borders of the serratus posterior inferior muscles.
5. Review the attachments and actions of the serratus posterior inferior muscle (see **TABLE 1.2**).
6. Use scissors to cut the medial attachments of the serratus posterior inferior muscle along the spinous processes of vertebrae T11–L2 (**Cut 2**) and reflect the muscle laterally leaving its attachments intact lateral to the angles of the ribs.

## Splenius Muscle

ATLAS 1.28, 1.33E; VIDEO 1.3.3

1. Refer to FIGURE 1.9.
2. Identify and clean the surface of the **splenius muscles** deep to the serratus posterior superior muscle. Observe that the fibers of the splenius muscles course obliquely across the neck from inferior to superior.
3. Identify the two parts of the splenius muscles named according to their superior attachments, the **splenius capitis** and **splenius cervicis**. *Note that the two parts of the splenius muscle are not easily distinguished from each other at this stage of the dissection.*
4. Review the attachments and actions of the splenius capitis and cervicis muscles (see **TABLE 1.2**).
5. Use sharp dissection to detach both parts of the splenius muscle from their inferior attachments on the nuchal ligament and spinous processes of vertebrae C7–T6 (**Cut 3**).
6. Reflect the splenius muscles laterally leaving their superior attachments undisturbed.

## Erector Spinae Muscles

ATLAS 1.28, 1.33; VIDEO 1.3.4

1. Refer to FIGURE 1.9.
2. To either side of the midline, identify the large collective mass of muscles referred to as the **erector spinae** deep to the investing fascia of the region, the **thoracolumbar fascia**.
3. Use scissors to carefully incise the posterior surface of the thoracolumbar fascia beginning at the midthoracic level (T6) and extending to the sacrum (S2). (**Cut 4**).
4. Observe that the thoracolumbar fascia is very thin at thoracic levels but becomes very thick at lumbar and sacral levels.
5. Use blunt dissection to separate and reflect the thoracolumbar fascia from the posterior surface of the erector spinae muscles.
6. Identify the **spinalis muscle**, the most medial column of the erector spinae; the **longissimus muscle**, the intermediate column of the erector spinae muscle; and the **iliocostalis muscle**, the lateral column of the erector spinae muscle.
7. Beginning at the midthoracic level, use blunt dissection to separate the three columns of the erector spinae.
8. Continue to gently separate the muscles within the erector spinae columns as far inferiorly as possible without ripping the tissue.

9. Observe that the columns of the erector spinae muscles are fused to each other at the level of the sacrum and ilium and cannot easily be separated.
10. Review the attachments and actions of the erector spinae muscles (see **TABLE 1.2**).

## Semispinalis Capitis Muscle

ATLAS 1.29; VIDEO 1.3.5

1. Refer to FIGURE 1.10.
2. Identify and clean the **semispinalis capitis muscle**, the most superficial member of the transversospinales group of muscles, which lies deep to the splenius capitis and cervicis muscles.
3. Observe that the fibers of the semispinalis capitis muscles course vertically, parallel to the vertebral column.
4. Review the attachments and actions of the semispinalis capitis muscle (see **TABLE 1.2**).
5. Find the **greater occipital nerve** where it penetrates the semispinalis capitis muscle.

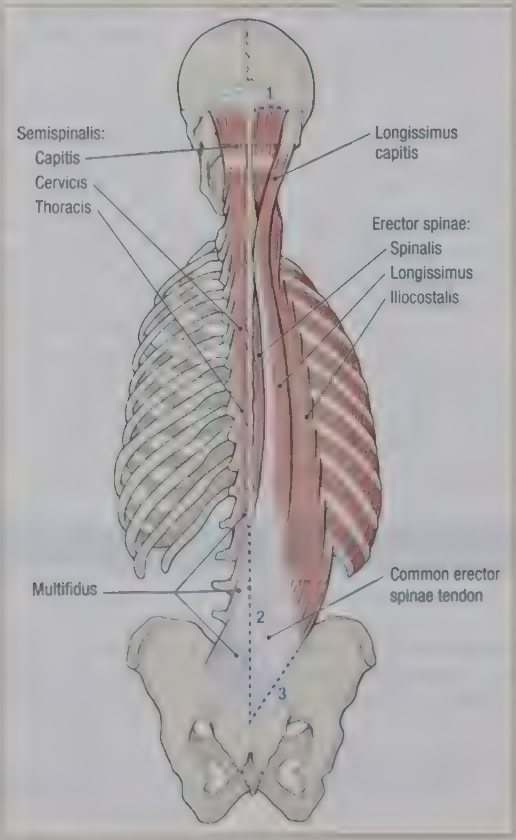


FIGURE 1.10 ● Deep muscles of the back isolated with erector spinae (*right*) and transversospinales muscles (*left*). Posterior view.

6. Use blunt dissection to follow the greater occipital nerve deeply through the semispinalis capitis muscle by widening the point of passage of the nerve through the muscle.
7. Detach the semispinalis capitis muscle close to the occipital bone while preserving the greater occipital nerve (**Cut 1**).
8. Reflect the semispinalis capitis muscle inferiorly while continuing to preserve the greater occipital nerve. *Note that it may be necessary to split the muscle around the nerve to facilitate reflection.*

## Semispinalis Cervicis Muscle

ATLAS 1.29; VIDEO 1.3.6

1. Refer to FIGURE 1.10.
2. Deep to the semispinalis capitis muscle, identify the **semispinalis cervicis muscle**.
3. Verify that the superior attachment of the semispinalis cervicis muscles is the spinous process of the axis (C2). *Note that the semispinalis muscle additionally has a thoracic component, semispinalis thoracis, but do not make an attempt to dissect it.*
4. Clean the superior extent of the semispinalis capitis muscle.
5. Review the attachments and actions of the semispinalis cervicis muscle (see **TABLE 1.2**).

## Multifidus Muscle

ATLAS 1.29, 1.31; VIDEO 1.3.7

1. Refer to FIGURE 1.10.
2. On one side of the body only, make a vertical incision through the erector spinae tendon along the ipsilateral lumbar spinous processes inferiorly to the median sacral crest at approximately the S2 vertebral level (**Cut 2**).
3. From the inferior extent of the vertical incision, make a superolateral incision through the erector spinae tendon from the median sacral crest to the PSIS (**Cut 3**) to create a "V"-shaped incision through the inferior extent of the attachments of the erector spinae tendon.
4. Detach the **common erector spinae tendon** from its inferior attachments on the lumbar and sacral spinous processes and reflect it superolaterally.
5. Identify and clean the **multifidus muscle** deep to the erector spinae tendon.
6. Observe that the multifidus muscle is very wide and thick over the sacrum and that it narrows in the lumbar region. *Note that the multifidus muscle has components in the lumbar, thoracic, and cervical regions and terminates superiorly at vertebral level C2. Do not follow it superiorly beyond the lumbar region.*
7. Review the attachments and actions of the multifidus muscle (see **TABLE 1.2**).

## Dissection Follow-up

1. Refer to **TABLE 1.2**.
2. Review the locations and actions of the intermediate group of back muscles.
3. Review the locations and actions of the deep back muscles (splenius, erector spinae, and transversospinales muscles).
4. Review the pattern of motor innervation to the deep group of back muscles.
5. Replace the intermediate and deep muscles of the back and any portion of reflected tissue back to their correct anatomical positions.

**TABLE 1.2 | Intermediate and Deep Muscles of the Back**

INTERMEDIATE GROUP OF BACK MUSCLES

| *Muscle* | *Medial Attachments* | *Lateral Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Serratus posterior superior | SP C7–T3 | Superior borders of ribs 2–5, lateral to their angles | Elevates ribs 2–5 | Anterior rami T2–T5 |
| Serratus posterior inferior | SP T11–L2 | Inferior border of ribs 9–12, lateral to their angles | Depresses ribs 9–12 | Anterior rami T9–T12 |

DEEP GROUP OF BACK MUSCLES

| *Muscle* | *Inferior Attachments* | *Superior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Splenius capitis | Ligamentum nuchae, SP C7–T4 | Mastoid process, lateral one-third of superior nuchal line | Unilateral—laterally flexes and rotates head or neck to same side<br>Bilateral—extends head and neck | Posterior rami of middle cervical nerves |
| Splenius cervicis | SP T3–T6 | TP C1–C3 | | |
| Spinalis | Median sacral crest, posterior surface sacrum, SP L and lower T, medial part iliac crest | SP of T and C | Unilateral—laterally flexes VT to same side<br>Bilateral—extends VT and head, stabilizes VT | Posterior rami of lower cervical nerves |
| Longissimus | | Between tubercles and angles of ribs, TP of T and C, and mastoid process | | |
| Iliocostalis | | Angles of lower ribs and TP of C | | |
| Semispinalis capitis | TP C7–T6/T7, AP C4–C6 | Between superior and inferior nuchal lines of occipital bone medially | Unilateral—extends and laterally rotates head to opposite side<br>Bilateral—extends head | Posterior rami of spinal nerves |
| Semispinalis cervicis | TP T1–T5/T6 | SP C2–C5 | Unilateral—extends and laterally rotates neck to opposite side<br>Bilateral—extends neck | |
| Multifidus | Sacrum, ilium, TP T1–L5, and AP C4–C7 | SP L5–C2 | Extends and rotates VT to opposite side | |

Abbreviations: AP, articular process; C, cervical vertebrae; L, lumbar vertebrae; SP, spinous process; T, thoracic vertebrae; TP, transverse process; VT, vertebral column.

# SUBOCCIPITAL REGION

## Dissection Overview

The suboccipital region is located at the base of the skull in the posterior neck and classified as the most superior aspect of the back. Four small muscles lie within a region commonly referred to as the suboccipital triangle: rectus capitis posterior major, rectus capitis posterior minor, obliquus capitis superior, and obliquus capitis inferior, all of which are innervated by the suboccipital nerve (C1).

The order of dissection will be as follows: The bones of the suboccipital triangle will be reviewed. The muscles that bound the suboccipital triangle will be identified. The contents of the suboccipital region (vertebral artery and suboccipital nerve) will be studied.

## Skeletal Anatomy

Refer to an articulated skeleton and identify the following skeletal features.

### *Suboccipital Region*

ATLAS 1.10B, 1.10C

1. Refer back to FIGURE 1.1 and to FIGURE 1.11.
2. On the posterior aspect of the skull, identify the **external occipital protuberance** and the bilaterally located **superior** and **inferior nuchal lines.**
3. Observe the relationship of the areas of muscle attachment between the nuchal lines and their proximity to the base of the skull and **foramen magnum**.
4. Observe that the **atlas** (C1) does not have a body and that the **axis** (C2) has the **dens**, the body of C1 that fused to C2 during development.
5. On the atlas (C1), identify the **posterior arch** and, approximately at the midpoint of the posterior arch, the **posterior tubercle.** Observe that unlike the other vertebrae, the atlas does not have a spinous process.
6. On the superior aspect of the posterior arch, identify the **groove for the vertebral artery** bilaterally and observe its relationship to the **transverse foramen** on the **transverse process.**
7. On the axis (C2), identify the bifid **spinous process**, the **transverse processes**, and the **transverse foramen**.

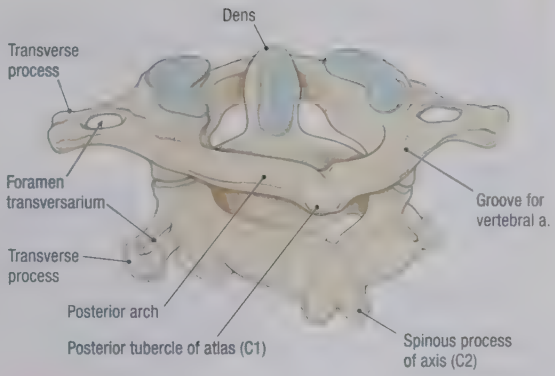


FIGURE 1.11 ● Atlas (C1) and axis (C2). Posterolateral view.

## Dissection Instructions

### Suboccipital Muscles

ATLAS 1.35A; VIDEO 1.4.1

***Dissection Note:*** The spinous process of C2 and the external occipital protuberance will be key landmarks for this dissection and should be used as points of reference for the suboccipital region.

1. Refer to FIGURE 1.12.
2. Identify the **spinous process of the axis (C2)** using the superior extent of the semispinalis cervicis muscle as a reference point.
3. Using the spinous process of the axis as a landmark, identify and clean the **obliquus capitis inferior muscle**, the inferior boundary of the suboccipital triangle.
4. Beginning superficially, use blunt dissection to follow the greater occipital nerve inferior to the inferior border of the **obliquus capitis inferior muscle** deeply. *Note that the greater occipital nerve (posterior ramus of C2) emerges between vertebrae C1 and C2.*
5. Using the spinous process of the axis as a landmark, identify and clean the **rectus capitis posterior major muscle**, the medial boundary of the suboccipital triangle.
6. Medial to the rectus capitis posterior major muscle, identify and clean the **rectus capitis posterior minor muscle.**
7. Beginning at the occipital bone, identify and clean the **obliquus capitis superior muscle**, the lateral boundary of the suboccipital triangle.
8. Review the attachments and actions of the suboccipital triangle muscles (see **TABLE 1.3**).

### Contents of the Suboccipital Triangle

ATLAS 1.36A; VIDEO 1.4.2

1. Refer to FIGURE 1.12.
2. On one side, identify and clean the **contents of the suboccipital triangle**, the **suboccipital nerve** and the **vertebral artery**. Remove any veins found within the suboccipital region.
3. Observe that the suboccipital nerve (posterior ramus of C1) emerges between the occipital bone and the atlas (C1 vertebra). *Note that the suboccipital nerve supplies motor innervation to all the muscles of the suboccipital region and is the only posterior ramus of a cervical spinal nerve with no cutaneous distribution.*
4. Deep within the suboccipital triangle, identify and clean the horizontal portion of the **vertebral artery** superior to the posterior arch of C1. Do not follow the vertebral artery superiorly or inferiorly at this point in the dissection; rather, use an illustration to study the course of the vertebral artery through the neck and into the skull.
5. To increase visibility of the path of the vertebral artery, detach the obliquus capitis superior and rectus capitis posterior major muscles from their attachments on the inferior nuchal line and reflect them laterally and inferiorly, respectively.

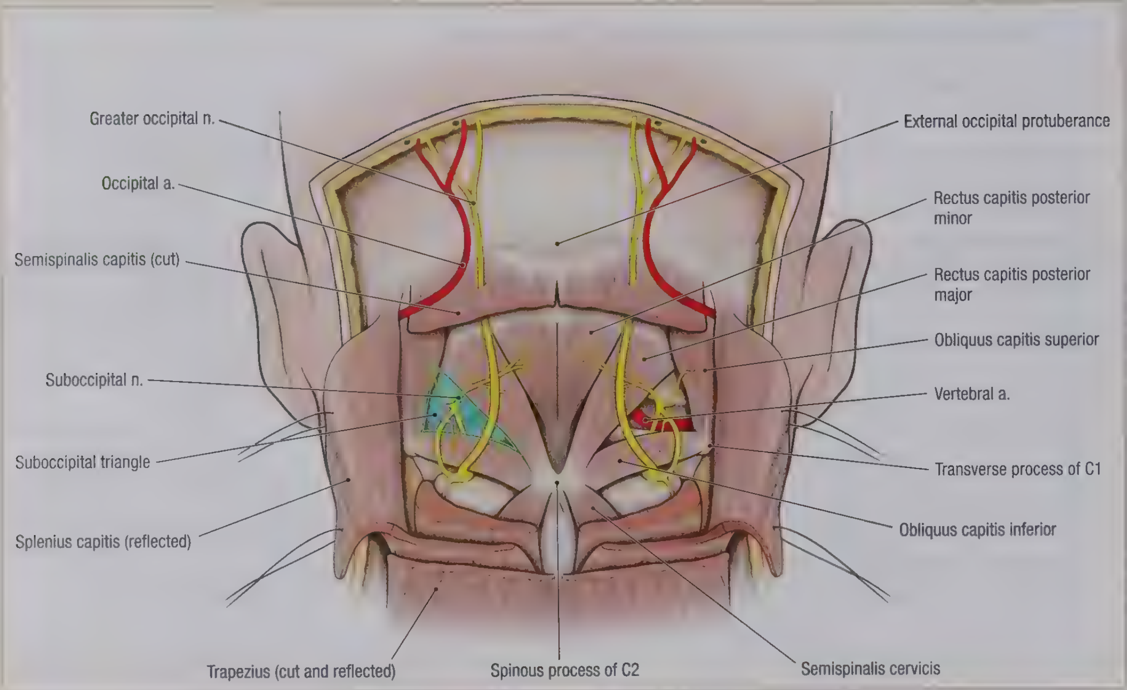

Greater occipital n.
Occipital a.
Semispinalis capitis (cut)
Suboccipital n.
Suboccipital triangle
Splenius capitis (reflected)
Trapezius (cut and reflected)
Spinous process of C2
Semispinalis cervicis
External occipital protuberance
Rectus capitis posterior minor
Rectus capitis posterior major
Obliquus capitis superior
Vertebral a.
Transverse process of C1
Obliquus capitis inferior

FIGURE 1.12 ■ Suboccipital region. Posterior view.

## Dissection Follow-up

1. Review the locations and actions of the suboccipital muscles in **TABLE 1.3**.
2. Review the path of the vertebral artery from the thorax to the posterior aspect of the brain and possible points of constriction.
3. Return any reflected suboccipital muscles, neck muscles, and any portions of reflected skin back in their correct anatomical positions.
4. Review the skeletal anatomy of C1 and C2.
5. Review the movements allowed between the skull and C1 (atlanto-occipital joint) and between C1 and C2 (atlanto-axial joint).

**TABLE 1.3 | Suboccipital Muscles**

SUBOCCIPITAL GROUP

| *Muscle* | *Medial Attachments* | *Lateral Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Rectus capitis posterior major | SP of C2 (axis) | Lateral inferior nuchal line of occipital bone | Extends head and rotates face to same side | Suboccipital n. (Posterior ramus C1) |
| Rectus capitis posterior minor | Posterior tubercle of C1 (atlas) | Medial inferior nuchal line of occipital bone | Extends head | |
| Obliquus capitis superior | TP of C1 (atlas) (inferior attachment) | Between lateral aspect of superior and inferior nuchal lines of occipital bone (superior attachment) | Extends head | |
| Obliquus capitis inferior | SP of C2 (axis) | TP of C1 (atlas) | Rotates face to same side | |

Abbreviations: C, cervical vertebrae; SP, spinous process; TP, transverse process.

# VERTEBRAL CANAL, SPINAL CORD, AND MENINGES

## Dissection Overview

The vertebral canal extends from the foramen magnum at the base of the skull through the stacked vertebral foramina of the cervical, thoracic, and lumbar vertebrae to terminate at the sacral hiatus. The vertebral canal encloses and protects the spinal cord, its membranes (spinal meninges), and blood vessels.

The spinal cord begins at the inferior extent of the brainstem within the skull at the level of the foramen magnum and terminates in the adult at the level between the first and second lumbar vertebrae. Thirty-one pairs of spinal nerves (8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal) arise from the spinal cord and emerge between adjacent vertebrae via the IV foramina. Two prominent enlargements are visible along the length of the spinal cord correlating to an increased amount of neural tissue: the cervical enlargement, corresponding to spinal cord segments C4–T1, which supply the upper limb, and the lumbar enlargement, corresponding to spinal cord segments L2–S3, which supply the lower limb, as shown in FIGURE 1.13.

The order of dissection will be as follows: The erector spinae and transversospinales muscles will be removed to expose the laminae of the vertebrae. The laminae will then be cut and removed (laminectomy) to expose the spinal meninges beginning at thoracic levels and extending into the sacrum. The spinal meninges will be examined and will be opened to expose the spinal cord. The spinal cord will then be studied.

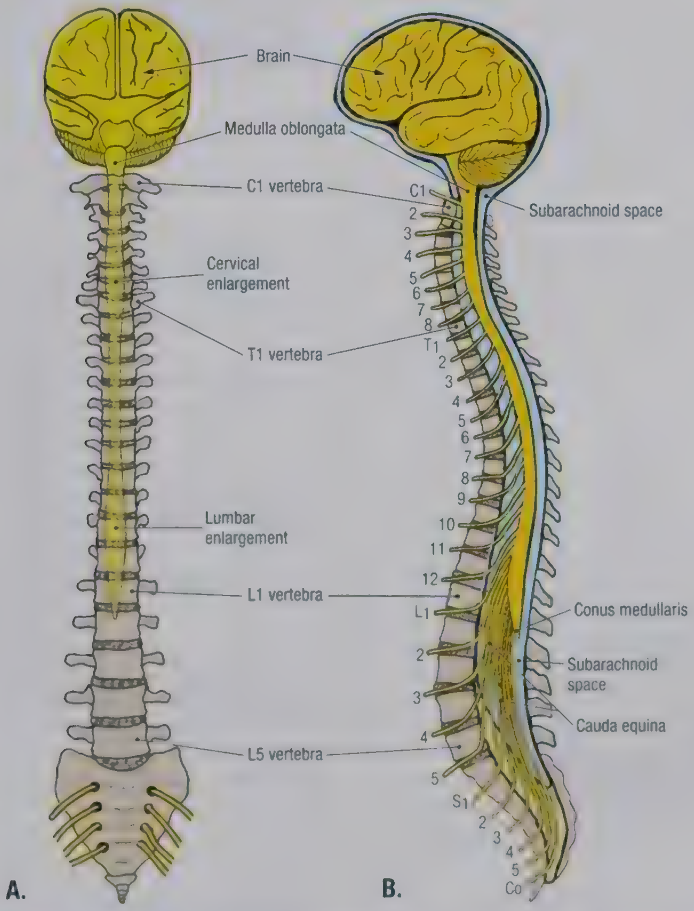

Brain
Medulla oblongata
C1 vertebra
Cervical enlargement
T1 vertebra
Lumbar enlargement
L1 vertebra
L5 vertebra
C1
2
3
4
5
6
7
8
T1
2
3
4
5
6
7
8
9
10
11
12
L1
2
3
4
5
S1
2
3
4
5
Co
Subarachnoid space
Conus medullaris
Subarachnoid space
Cauda equina
A.
B.

FIGURE 1.13 ● Spinal cord within vertebral canal. A. Anterior view. B. Lateral view.

## Dissection Instructions

***Dissection Note:*** Perform the following dissection instructions bilaterally and wear eye protection for all steps that require the use of a chisel, bone saw, or bone cutters.

### Laminectomy

ATLAS 1.37; VIDEO 1.5.1

1. Refer to FIGURE 1.14.
2. Use a scalpel to remove the erector spinae and transversospinales muscles bilaterally from vertebral levels T4–S3. To facilitate the removal of the muscles, make a horizontal cut with the scalpel at the level of T4. Elevate the superior edge of the cut muscles and reflect the entire group of muscles inferiorly. As you progress inferiorly, detach the muscles from the vertebral column to cleanly expose the laminae.
3. Use scraping motions with a chisel to clean the remaining muscle fragments off the laminae.
4. Begin the laminectomy in the thoracic region. Use a chisel or power saw to cut the laminae of vertebrae T6–T12 on both sides of the spinous processes. Make this cut at the lateral end of the laminae to gain wide exposure to the vertebral canal. The cutting instrument should be angled at 45° to the vertical to maximize exposure of the vertebral canal. Be careful to not cut through the transverse processes and thus enter the thoracic cavity.
5. Use a scalpel to cut the **interspinous ligament** between vertebrae T6 and T7 and between vertebrae T12 and L1. Preserve the interspinous ligaments between T7 and T12 levels to keep the intervening spines together upon removal.

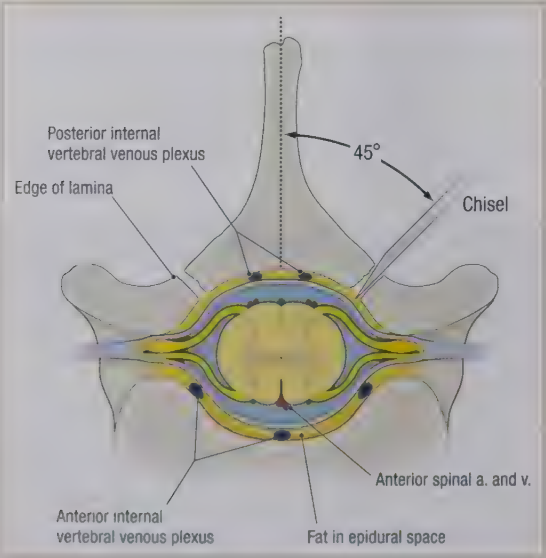

Posterior internal vertebral venous plexus
Edge of lamina
45°
Chisel
Anterior spinal a. and v.
Anterior internal vertebral venous plexus
Fat in epidural space

FIGURE 1.14 ■ Laminectomy cuts into vertebral canal. Inferior view.

CLINICAL CORRELATION

### Lumbar Puncture and Epidural Anesthesia

ATLAS 1.38

Cerebrospinal fluid (CSF) can be readily obtained in the adult from the subarachnoid space by inserting a needle between vertebral levels L3 and L4, or between L4 and L5, a procedure known as a lumbar puncture as represented in FIGURE B1.1. The lower lumbar vertebral levels are relatively safe as the spinal cord terminates as the conus medullaris at the L1/L2 IV disc in the adult, and below L2 within the cauda equina, there is little to no danger of penetrating the nervous tissue with the puncture needle. A lumbar injection may similarly be performed in the lower lumbar region to safely introduce anesthesia into the epidural space. Epidural injections provide spinal anesthesia to block sensations of pain for childbirth or surgery.

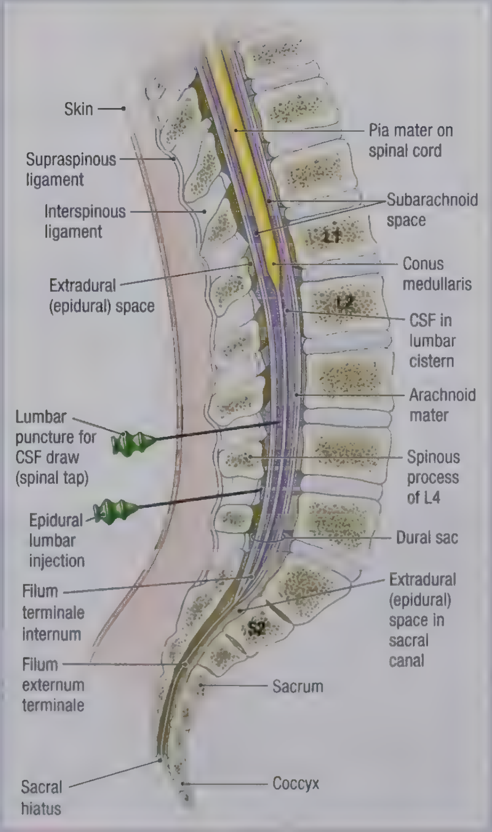

Skin
Supraspinous ligament
Interspinous ligament
Extradural (epidural) space
Lumbar puncture for CSF draw (spinal tap)
Epidural lumbar injection
Filum terminale internum
Filum externum terminale
Sacral hiatus
Pia mater on spinal cord
Subarachnoid space
L1
Conus medullaris
L2
CSF in lumbar cistern
Arachnoid mater
Spinous process of L4
Dural sac
Extradural (epidural) space in sacral canal
S2
Sacrum
Coccyx

FIGURE B1.1 ■ Spinal cord and dural sac in vertebral canal. Midsagittal view.

6. Use a chisel to pry the spinous processes and their laminae out as a unit paying attention to not damage the underlying structures. If done properly, the dura mater will remain in the vertebral canal with the spinal cord and will be undamaged.
7. On the deep surface of the removed spinous specimen, identify the **ligamenta flava**. Observe that the ligamenta flava and interspinous ligaments connect the laminae and spinous processes of adjacent vertebrae, whereas the **supraspinous ligament** connects all the spinous processes from the sacrum to the C7 vertebral level. At C7, the supraspinous ligament blends with the ligamentum nuchae, which continues to the external occipital protuberance.
8. Use a chisel to widen the canal and remove any sharp edges of bone remaining after the initial cuts.
9. Continue the laminectomy procedure inferiorly in the lumbar and sacral regions to vertebral level S3. Use direct observation of the exposed vertebral canal to help you make the cuts correctly. Due to the curvature of the vertebral column, the lower lumbar levels may be quite deep. Exercise caution in lower lumbar and sacral regions because the vertebral canal curves sharply posteriorly (superficially).
10. Make a "V"-shaped incision in the posterior surface of the sacrum with the inferior point of the wedge terminating at vertebral level S3. Do not drive the chisel or push the saw through the sacrum because the tool may penetrate the rectum.
11. Use a chisel to pry the spinous processes and their laminae out as a unit, paying attention to not damage the underlying structures, and place the removed spinous specimen in the tissue container.
12. When finished with the laminectomy, you should see the posterior surface of the dura mater from vertebral levels T6–S2.

## Spinal Meninges

ATLAS 1.38A, 1.39; VIDEO 1.5.2

1. Once the laminectomy is completed, the **epidural (extradural) space** is exposed. The epidural space contains fat and veins that may be difficult to identify due to the embalming process. Use blunt dissection to remove the **epidural fat** and the **posterior internal vertebral venous plexus** from the epidural space.

**CLINICAL CORRELATION**

### Vertebral Venous Plexuses

ATLAS 1.44A, 1.44B

The veins of the vertebral venous plexus do not have valves that regulate the flow of blood. Due to the lack of valves, the vertebral venous plexus drains based on pressure gradients and can serve as routes for the spread of infection or metastasis of cancer from breast tissue in the thoracic region or from pelvic tissue to the vertebrae, vertebral canal, and cranial cavity.

2. Identify the **dura mater**, the external meningeal layer. Observe that the **dural sac** ends inferiorly at vertebral level S2.
3. In the thoracic region, lift a fold of **dura mater** with forceps and use scissors to cut a small opening in its posterior midline. Use scissors to extend the cut inferiorly to vertebral level S2. Attempt to do this without damaging the underlying arachnoid mater by retracting the dura mater laterally as you progress inferiorly.
4. Identify the middle meningeal layer, the **arachnoid mater**. Observe that the arachnoid mater is very delicate and thin compared to the overlying protective dura mater.
5. Incise the arachnoid mater in the posterior midline and observe the **subarachnoid space**. *Note that the subarachnoid space contains CSF in the living person but not in the cadaver as it drains during the embalming process.*
6. Refer to FIGURE 1.15.
7. Retract the arachnoid mater and identify the **spinal cord**. Observe that the spinal cord is completely invested by the internal meningeal layer, the **pia mater**. *Note that the pia mater is the thinnest of the meningeal layers, lies directly on the surface of the spinal cord, and cannot be dissected.*
8. On the spinal cord at lower thoracic vertebral levels, identify the **lumbar enlargement** (spinal cord segments L2–S3) providing nerves to the lower limb.
9. Inferior to the lumbar enlargement, identify the **conus medullaris (medullary cone)** demarcating the end of the spinal cord between vertebral levels L1 and L2.
10. Identify the collection of anterior and posterior nerve roots surrounding the conus medullaris in the lower vertebral canal forming the **cauda equina**, the collection of nervous tissue resembling a horse's tail within the dural sac.

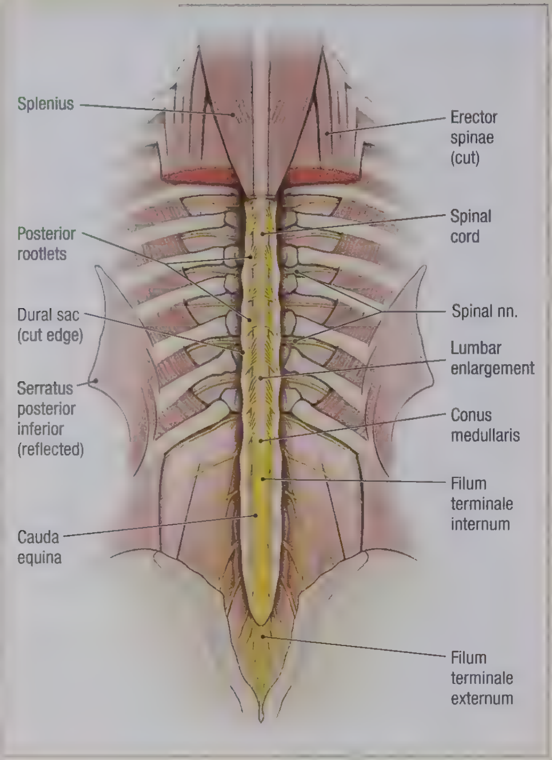

Splenius
Erector spinae (cut)
Posterior rootlets
Spinal cord
Dural sac (cut edge)
Spinal nn.
Lumbar enlargement
Serratus posterior inferior (reflected)
Conus medullaris
Filum terminale internum
Cauda equina
Filum terminale externum

FIGURE 1.15 ● Exposure of lower vertebral canal, spinal cord, and cauda equina. Posterior view.

11. Centrally within the cauda equina, identify the **filum terminale internum**, a delicate filament of pia mater arising from the tip of the conus medullaris and ending at vertebral level S2.
12. Observe that inferiorly, the filum terminale internum becomes encircled by the lower end of the dural sac and continues as the **filum terminale externum (coccygeal ligament)** below vertebral level S2. *Note that the filum terminale externum passes through the sacral hiatus and ends by attaching to the coccyx.*
13. Refer to FIGURE 1.16.
14. The pia mater forms two **denticulate ligaments**, one on each side of the spinal cord. *Note that each denticulate ligament has 21 teeth, each of which is attached to the inner surface of the dura mater anchoring the spinal cord laterally.*
15. Use a probe to follow the **posterior** and **anterior roots** to the point where they pierce the dura mater and enter the **IV foramen**. Observe that the posterior roots are on the posterior side of the denticulate ligament, whereas the anterior roots are on the anterior side of the denticulate ligament.
16. Follow the posterior roots medially to observe that they are formed by the merging of **posterior rootlets**.
17. Observe that the anterior roots are also formed by **anterior rootlets**, although visibility may be somewhat restricted due to the orientation of the spinal cord.
18. Make an effort to observe the small **blood vessels** coursing along the anterior and posterior roots. Depending on the vertebral level, the small blood vessels may be branches of posterior intercostal, lumbar, or vertebral arteries. The arteries pass into the vertebral canal via the IV foramen and supply blood to the spinal cord.
19. In the thoracic region, expose one **spinal nerve** by removing portions of the surrounding tissue.

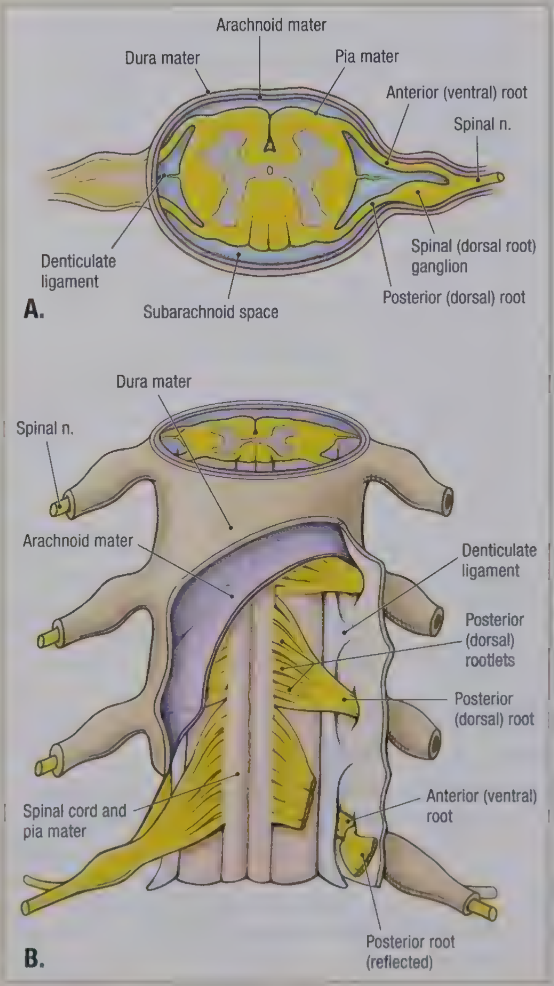

Arachnoid mater
Dura mater
Pia mater
Anterior (ventral) root
Spinal n.
Denticulate ligament
Spinal (dorsal root) ganglion
Posterior (dorsal) root
A.
Subarachnoid space
Dura mater
Spinal n.
Arachnoid mater
Denticulate ligament
Posterior (dorsal) rootlets
Posterior (dorsal) root
Spinal cord and pia mater
Anterior (ventral) root
B.
Posterior root (reflected)

FIGURE 1.16 ● **A.** Axial section of spinal cord. Inferior view. **B.** Relationships of the meninges to the spinal cord, spinal nerves, roots, and rootlets. Posterior view.

To protect the spinal nerve during this process, place a probe into the IV foramen posterior to the nervous tissue and then remove anything overlying the instrument.

20. Remove the probe and use bone cutters to remove the posterior wall of the IV foramen and expose the **spinal (dorsal root) ganglion**. *Note that the spinal ganglion is the location of the sensory cell bodies of the spinal nerves.*
21. Distal to the spinal ganglion, identify the spinal nerve, the point where the posterior and anterior roots merge.
22. Follow the spinal nerve distally a short distance to the point where it divides into a **posterior ramus** and an **anterior ramus**. *Note that the posterior ramus will supply the deep muscles of the back and the overlying skin, whereas the ventral ramus will be responsible for the anterolateral trunk and limbs.*

## Dissection Follow-up

1. Review the formation and branches of a typical spinal nerve.
2. Review the pattern of motor innervation to the deep back muscles as compared to the superficial muscles of the back.
3. Review the coverings and parts of the spinal cord and study an illustration that shows the blood supply to the spinal cord.
4. Consult a dermatome chart and relate this pattern of cutaneous innervation to the spinal cord segments.

## CHAPTER 2

# The Upper Limb

**REFERENCES**

ATLAS = *Grant's Atlas of Anatomy*, 15th ed., figure number

VIDEO = *Grant's Dissection Videos*, video sequence number

The upper limb extends from the shoulder to the tips of our fingers and is divided into four regions: shoulder (pectoral girdle), arm (brachium), forearm (antebrachium), and hand (manus). The upper limb is structured for mobility so we can place our hands, fundamentally grasping organs, in a variety of orientations within a large area of space. Some of the muscles that control the upper limb are intrinsic, originate and terminate within the upper limb, and some are extrinsic, originate in the thorax or back and terminate within the upper limb.

With the body prone, commence the dissection of the upper limb with the scapular region. Beginning with the scapular region minimizes the number of full body rotations required and continues the study of the superficial muscles of the back into the upper limb.

### CLINICAL CORRELATIONS

During the course of your dissection protocol, you may encounter anatomical variations, clinical conditions, disease processes, or medical devices in your cadaveric donor. The following select clinical correlations will be described in more detail throughout this chapter.

**The Upper Limb**

1. Rotator Cuff Tear, see the **Rotator Cuff Muscles** sequence. ATLAS 2.33E
2. Breast Cancer and Quadrants, see the **Breast** sequence. ATLAS 3.4
3. Nerve Injuries (Long Thoracic, Thoracodorsal, and Axillary Nerve Neuropathies), see the **Brachial Plexus** sequence. ATLAS 2.4, 2.29, 2.44B
4. Brachial Artery Variants and Damage, see the **Neurovasculature of the Arm** sequence. ATLAS 2.8A, 2.39, 2.59
5. Nerve Injuries (Radial, Median, and Ulnar Nerve Neuropathies), see the **Vessels and Nerves of the Anterior Forearm** sequence. ATLAS 2.41
6. Carpal Tunnel Syndrome, see the **Carpal Tunnel** sequence. ATLAS 2.74, 2.98
7. Recurrent Branch of the Median Nerve, see the **Thenar Muscles** sequence. ATLAS 2.71, 2.74
8. Joint Injuries (Dislocated and Separated Shoulder), see the **Glenohumeral Joint** sequence. ATLAS 2.46, 2.47

## SKIN AND SUPERFICIAL MUSCLES OF THE BACK

If the upper limb is your first dissection unit, place the cadaver in a prone position and follow the dissection protocols outlined in Chapter 1 for **Skin and Superficial Fascia** and the **Superficial Muscles of the Back**. Following completion of the superficial muscles of the back dissection, turn the cadaver to a supine position and return to this page.

# SHOULDER REGION AND POSTERIOR ARM

## Dissection Overview

There are six shoulder (scapulohumeral) muscles: deltoid, supraspinatus, infraspinatus, teres major, teres minor, and subscapularis, which are attached between the scapula and the humerus. The triceps brachii muscle, located within the posterior compartment of the arm (brachium), passes between the attachment sites of the two teres muscles to create spaces, or windows, through which neurovascular structures may be found. The anconeus muscle, the other posterior compartment muscle of the arm, will be studied with the posterior compartment of the forearm (antebrachium). Further examination of the fascia, contents, and organization of the arm will be studied when the anterior compartment of the arm is dissected.

The order of dissection will be as follows: The skeletal anatomy of the scapula and proximal humerus will be studied. The deltoid muscle will be studied and detached from a portion of its proximal attachment, and the course of its nerve and artery will be explored. The four muscles arising from the posterior surface of the scapula (supraspinatus, infraspinatus, teres major, teres minor) will be dissected, and their nerves and blood vessels will be demonstrated. The quadrangular and triangular space boundaries and contents will be identified. The posterior compartment of the arm will be cleaned and studied.

### Skeletal Anatomy

Refer to an articulated skeleton or disarticulated scapula and humerus to identify the following skeletal features.

#### Posterior Scapula

ATLAS 2.3D, 2.3E, 2.3F

1. Refer to FIGURE 2.1.
2. On the posterior aspect of the scapula, identify the **spine of the scapula** and observe that it separates the **supraspinous fossa** from the **infraspinous fossa** and terminates laterally as the **acromion process**.
3. Along the superior border of the scapula, identify the **suprascapular notch** along the anterior aspect of the supraspinous fossa.
4. On the lateral aspect of the scapula, inferior to the acromion, identify the **glenoid cavity** forming the "socket" of the glenohumeral joint.
5. Superior and inferior to the depression of the glenoid cavity, identify the **supraglenoid** and **infraglenoid tubercles**, respectively. *Note that the roughened regions of the tubercles serve as attachment sites for muscles of the upper limb.*

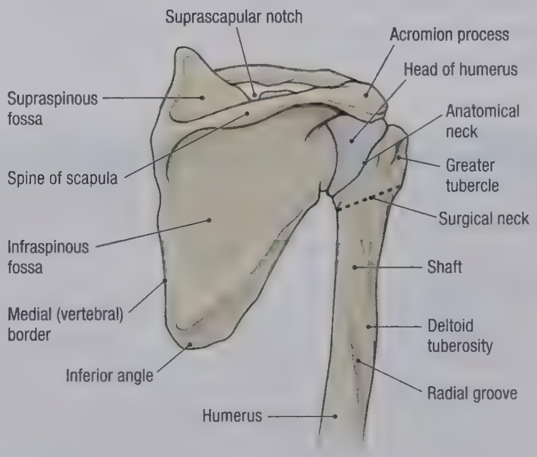


FIGURE 2.1 ● Skeleton of the right shoulder. Posterior view.

#### Proximal Posterior Humerus

ATLAS 2.3E

1. On the proximal aspect of the humerus medially, identify the smooth surface of the **head of the humerus**, the "ball" of the ball-and-socket glenohumeral joint.
2. Immediately inferior to the head of the humerus, locate the **anatomical neck** coursing obliquely through the thick portion of the bone, the epiphysis.
3. Inferior to the greater and lesser tubercles, where the bone begins to narrow, identify the **surgical neck of the humerus**.
4. Identify the **shaft** of the humerus and the **deltoid tuberosity** along its lateral aspect.
5. On the posterior surface of the shaft, identify the **radial groove** coursing obliquely.

### Surface Anatomy

The surface anatomy of the shoulder may be studied on a living subject or on a cadaver. On the cadaver, note that fixation of tissue during embalming may make it difficult to distinguish bone from well-preserved soft tissues in some specimens.

### Posterior Shoulder

ATLAS 2.30

1. Refer to FIGURE 2.2.
2. Place the cadaver in the prone (face down) position.
3. Palpate the **spine of the scapula** coursing horizontally along an oblique line and observe that it subdivides the scapular region into a portion superior (supraspinous) and inferior (infraspinous) to it.
4. Progress medially from the spine of the scapula toward the **medial (vertebral) border of the scapula.** *Note that the medial aspect of the spine of the scapula is approximately at the T3 vertebral level.*
5. Follow the medial border of the scapula inferiorly toward the **inferior angle of the scapula** (at vertebral level T7).
6. Progress laterally from the inferior angle along the path of the latissimus dorsi and observe that it forms the **posterior axillary fold.** *Note that the lateral (axillary) border of the scapula is not readily palpable because the latissimus dorsi, teres major, and teres minor lie along the lateral aspect of the scapula.*
7. Return to the spine of the scapula and palpate laterally to the **acromion process of the scapula.** Observe that the acromion process is a palpable landmark of the shoulder and that it articulates anteriorly with the **lateral (acromial) end of the clavicle** at the **acromioclavicular (AC) joint.**
8. Palpate the triangular-shaped **deltoid** muscle along the posterior aspect of the shoulder and observe that it attaches inferior to the spine, the acromion of the scapula, and the lateral aspect of the clavicle.
9. Identify the inferior aspect of the deltoid and observe that it attaches to the **deltoid tuberosity of the humerus.**
10. Using the deltoid as a landmark, palpate the muscles within the **anterior** and **posterior compartments of the arm.**

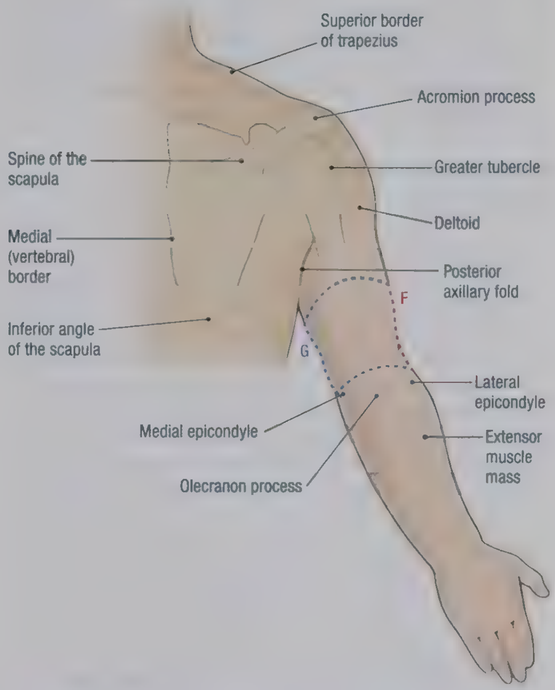


FIGURE 2.2 ● Surface anatomy of the shoulder. Posterior view.

## Dissection Instructions

### Skin Incisions of the Posterior Arm

VIDEO 2.1.1

***Dissection Note:*** Prior to commencing with skin incisions, decide to perform either a full- or partial-thickness approach and to either reflect or remove the skin from the dissection field. See **Removing the Skin** in the **Introduction Chapter** for descriptions.

1. Refer back to FIGURE 2.2.
2. With the cadaver in the prone position, abduct the upper limb to 45°. If a block is available, place it under the chest and shoulder to facilitate dissection of the region.
3. Use a scalpel to make a skin incision along the medial aspect of arm from the midpoint of the arm (G) to a point just superior to the medial epicondyle of the humerus.
4. Beginning near the medial epicondyle where the vertical incision stopped, make a shallow incision around the posterior surface of the elbow toward the lateral aspect of the limb parallel to the cut along the posterior aspect of the arm (G to F).

***Dissection Note:*** If reflecting the skin, skip step 5.

5. Make a vertical incision from the midpoint of the arm laterally (F) to the horizontal incision made posterior to the elbow just superior to the lateral epicondyle.
6. Reflect the skin of the posterior arm from medial to lateral using either a pair of locking forceps or the buttonhole technique.
7. Perform either a full- or partial-thickness reflection of the skin and superficial fascia to expose the underlying deep fascia covering the muscles of the posterior compartment of the arm.

8. If reflecting the skin, utilize the uncut sections of skin laterally as hinge points to leave the skin attached along the peripheral aspect of the arm.
9. If removing the skin, once the lateral incision points are reached, detach the skin and subcutaneous tissue and place it in the tissue container.

## Posterior Shoulder Muscles

ATLAS 2.31A, 2.42; VIDEO 2.1.2

1. Refer to FIGURE 2.3.
2. Reflect the trapezius muscle superiorly, leaving it attached along the clavicle and "hinge" of cervical fascia created during the back dissection.
3. Clean the surface and borders of the **deltoid muscle**.
4. Review the attachments and actions of the deltoid muscle (see **TABLE 2.1**).
5. Use a scalpel to detach the deltoid muscle from its proximal attachments along the inferior aspect of the spine of the scapula and acromion process. Leave the deltoid muscle attached anteriorly along the clavicle and inferiorly where it attaches to the humerus at the deltoid tuberosity.
6. Reflect the deltoid muscle laterally, taking care not to tear the vessel and nerve branches coursing along its deep surface.
7. Identify the **axillary nerve** and the **posterior circumflex humeral artery and vein** on the deep surface of the deltoid muscle near the surgical neck of the humerus. *Note that the axillary nerve innervates the deltoid muscle and the* ***teres minor muscle****.*
8. Clean the axillary nerve and posterior circumflex humeral vessels using blunt dissection and trace them for a short distance around the posterior aspect of the surgical neck of the humerus medially.
9. Follow the axillary nerve and the posterior circumflex humeral vessels deeply into the **quadrangular space**.
10. Observe that the **quadrangular space** is bound superiorly by the **teres minor muscle**, inferiorly by the **teres major muscle**, and medially by the lateral border of the **long head of the triceps brachii muscle**. The lateral border of the quadrangular space is the surgical neck of the humerus, which cannot be seen at this time.
11. Identify and clean the proximal end of the **long head of the triceps brachii muscle**. Observe that the long head passes posterior to the teres major muscle and anterior to the teres minor muscle to insert at the infraglenoid tubercle of the scapula.
12. Clean and define the borders of the **teres major muscle.** If the teres major is partially covered by the latissimus dorsi muscle, simply loosen the connective tissue surrounding the latissimus dorsi to gently pull it laterally.
13. Review the attachments and actions of the teres major muscle (see **TABLE 2.1**).

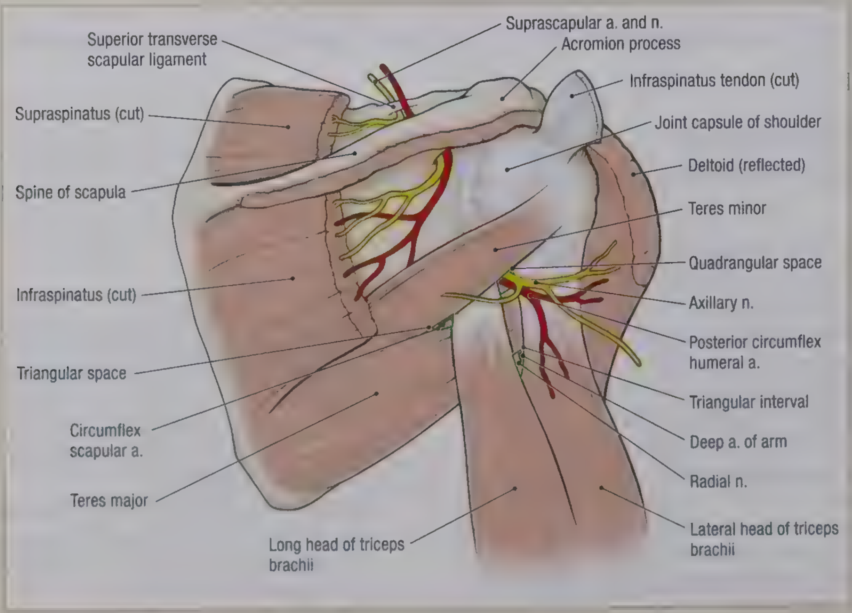

Superior transverse scapular ligament
Suprascapular a. and n.
Acromion process
Infraspinatus tendon (cut)
Supraspinatus (cut)
Joint capsule of shoulder
Deltoid (reflected)
Spine of scapula
Teres minor
Quadrangular space
Infraspinatus (cut)
Axillary n.
Posterior circumflex humeral a.
Triangular space
Triangular interval
Circumflex scapular a.
Deep a. of arm
Radial n.
Teres major
Long head of triceps brachii
Lateral head of triceps brachii

FIGURE 2.3 ● Neurovasculature of the shoulder. Posterior view.

## Rotator Cuff Muscles

ATLAS 2.33, 2.47; VIDEO 2.1.3

1. Refer to FIGURE 2.3.
2. The four muscles of the **rotator cuff** are the **supraspinatus**, **infraspinatus**, **teres minor**, and **subscapularis**. *Note that the subscapularis muscle will be dissected with the axilla.*
3. Identify and clean the **teres minor muscle** along the lateral border of the scapula. Make an effort to clearly define its superior and inferior borders but not its medial and lateral.
4. Clean the surface and define the borders of the **infraspinatus muscle** within the infraspinous fossa of the scapula.
5. Review the attachments and actions of the teres minor and infraspinatus muscles (see **TABLE 2.1**).
6. Observe that the **triangular space** is medial to the quadrangular space and is bound superiorly by the inferior border of the teres minor muscle, inferiorly by the superior border of the teres major muscle, and laterally by the medial border of the long head of the triceps brachii muscle.
7. Identify the circumflex scapular artery and vein within the triangular space. Make no deliberate effort to follow the vessel at this time.
8. Clean and define the borders of the **supraspinatus muscle** within the suprascapular fossa.
9. Review the attachments and actions of the supraspinatus muscle (see **TABLE 2.1**).

**CLINICAL CORRELATION**

### Rotator Cuff Tear

ATLAS 2.33E

Repetitive use of the glenohumeral joint may lead to recurrent inflammation resulting in shoulder pain and commonly a tear through the tendinous attachment of one of the rotator cuff muscles. The most commonly torn tendon is the supraspinatus muscle where it courses superior to the glenohumeral joint. The supraspinatus is often torn not only due to its action of assisting in upper limb abduction, a common action, but also because its tendon is in a largely avascular region of the joint.

10. Use a scalpel to transect the supraspinatus muscle about 5 cm lateral to the superior angle of the scapula but medial to the suprascapular notch. If a disarticulated scapula is available, hold it over the scapula of the cadaver to help you locate the proper level of the cut.
11. Use blunt dissection to loosen and reflect the lateral portion of the supraspinatus muscle from the supraspinous fossa.

## Suprascapular Artery and Nerve

ATLAS 2.42, 2.43; VIDEO 2.1.4

1. Refer to FIGURE 2.3.
2. Identify the **suprascapular artery and nerve** that lie in the supraspinous fossa.
3. Follow the artery and nerve anteriorly to demonstrate their relationship with the **superior transverse scapular ligament**. Observe that the suprascapular artery passes superior to the superior transverse scapular ligament and that the suprascapular nerve passes inferior to it. This relationship can be remembered by use of a mnemonic: *A*rmy (*a*rtery) goes over the bridge; *N*avy (*n*erve) goes under the bridge, with the "bridge" being the superior transverse scapular ligament.
4. Transect the **infraspinatus muscle** about 5 cm lateral to the medial border of the scapula.
5. Use blunt dissection to loosen and reflect the lateral portion of the infraspinatus muscle from the infraspinous fossa.
6. Follow the **suprascapular artery** and the **suprascapular nerve** around the spine of the scapula deep to the acromion process to the infraspinous fossa where they supply the infraspinatus muscle.
7. Observe that the suprascapular artery sends branches to the circumflex scapular artery and thus contributes to the collateral circulation of the scapular region as part of the scapular anastomoses.

## Posterior Compartment of the Arm

ATLAS 2.41, 2.42; VIDEO 2.1.5

1. Refer to FIGURE 2.4.
2. With the cadaver in the prone position, rotate the upper limb medially to gain better access to the posterior compartment of the arm.
3. Use sharp dissection to open the posterior compartment of the arm by making a longitudinal incision through the deep (brachial) fascia from the teres minor muscle superiorly to the level of the olecranon of the ulna inferiorly.
4. Use blunt dissection to spread and elevate the cut edges of the brachial fascia.
5. On the periphery of the arm, detach the brachial fascia from the medial and lateral intermuscular septa and place it in the tissue container.
6. Identify the **triceps brachii muscle** and note the arrangement of its three muscular heads. Observe that the **long head of the triceps brachii muscle** is positioned more superficially than the **lateral** and **medial heads of the triceps brachii** muscle, so named for their location respective to the radial groove.
7. Review the attachments and actions of the triceps brachii muscle (see **TABLE 2.1**).

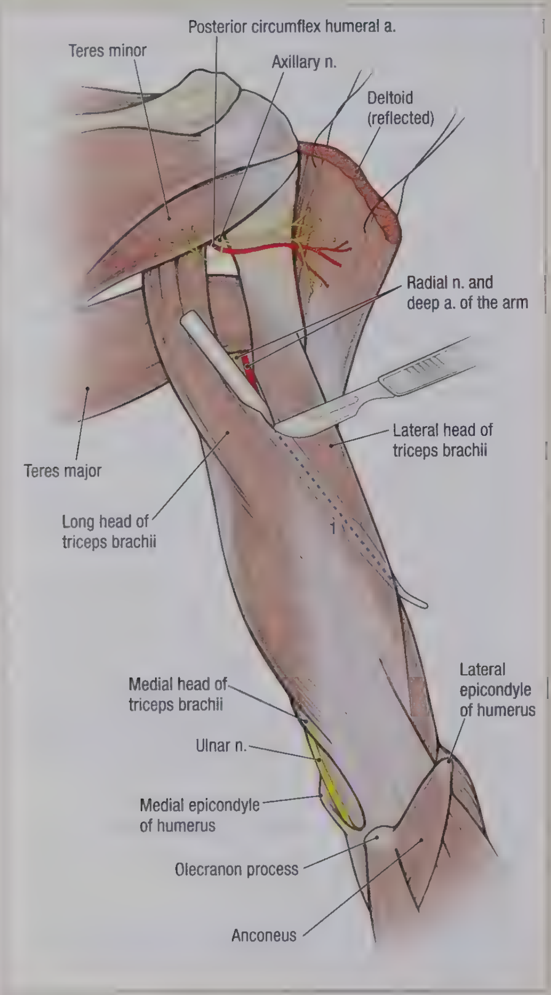

Posterior circumflex humeral a.
Teres minor
Axillary n.
Deltoid (reflected)
Radial n. and deep a. of the arm
Lateral head of triceps brachii
Teres major
Long head of triceps brachii
Lateral epicondyle of humerus
Medial head of triceps brachii
Ulnar n.
Medial epicondyle of humerus
Olecranon process
Anconeus

FIGURE 2.4 ● Shoulder and posterior compartment of the arm. Posterior view.

8. Use blunt dissection to separate the long head from the lateral head of the triceps brachii inferior to where the teres major muscle crosses the anterior surface of the long head.
9. Observe that the **triangular interval** is inferior to the quadrangular space and that it is bound medially by the long head of the triceps brachii muscle, laterally by the lateral head of the triceps brachii muscle, and superiorly by the inferior border of the teres major muscle.
10. Widen the triangular interval and identify the **radial nerve** and the **deep artery of the arm (deep brachial artery)** within the space.
11. Push a probe distally along the course of the radial nerve between the lateral head of the triceps brachii muscle and the humerus.
12. On one side of the body only, use a scalpel to transect the lateral head of the triceps brachii where it merges with the long head over the probe.
13. Spread apart the heads of the triceps and use blunt dissection to clean the radial nerve and the deep artery of the arm within the **radial groove** of the humerus. Do not follow the radial nerve or deep artery of the arm distally at this time. The path of the radial nerve will be continued in the dissection of the cubital fossa.

## Dissection Follow-up

1. Review the innervations and attachments of the scapulohumeral muscles in **TABLE 2.1**.
2. List the action of each muscle of the rotator cuff individually as well as the combined action of the rotator cuff group of muscles.
3. Review the origin, course, and distribution of the transverse cervical artery, dorsal scapular artery, and suprascapular artery and their roles in the scapular anastomoses.
4. Review the relationship of the suprascapular artery and the suprascapular nerve to the superior transverse scapular ligament.
5. Review the boundaries and contents of the triangular space, the quadrangular space, and the triangular interval.
6. Replace the muscles of the scapular region and posterior arm in their correct anatomical positions.

TABLE 2.1 Muscles of the Shoulder and Posterior Arm

SCAPULAR REGION

| *Muscle* | *Medial Attachments* | *Lateral Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Deltoid | Spine of the scapula, acromion of the scapula, lateral one-third of the clavicle | Deltoid tuberosity of the humerus | Abducts, flexes, and extends the humerus | Axillary n. |
| Supraspinatus | Supraspinous fossa of the scapula | Superior facet of the greater tubercle of the humerus | Abducts the humerus | Suprascapular n. |
| Infraspinatus | Infraspinous fossa of the scapula | Middle facet of the greater tubercle of the humerus | Laterally rotates the humerus | Suprascapular n. |
| Teres major | Inferior angle of the scapula | Medial lip of the intertubercular sulcus of the humerus | Adducts and medially rotates the humerus | Lower subscapular n. |
| Teres minor | Lateral border of the scapula | Inferior facet of the greater tubercle of the humerus | Laterally rotates the humerus | Axillary n. |
| Subscapularis | Subscapular fossa | Lesser tubercle of the humerus | Medially rotates the humerus | Upper and lower subscapular nn. |

POSTERIOR COMPARTMENT OF THE ARM

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Triceps brachii | Long head—infraglenoid tubercle of the scapula; medial and lateral heads—posterior surface of the humerus | Olecranon process of the ulna | Extends the forearm; long head—extends and adducts the arm | Radial n. |

Abbreviations: n., nerve; nn., nerves.

# PECTORAL REGION AND SUPERFICIAL FASCIA OF THE UPPER LIMB

## Dissection Overview

The pectoral region covers portions of the anterior and lateral thoracic walls. The breast, a major content of the pectoral region, extends from the lateral border of the sternum to the midaxillary line, and from ribs 2 to 6. The breast is positioned anterior to the pectoral fascia (the deep fascia of the pectoralis major muscle) and separated from the underlying muscle and fascia by the retromammary space. The breast tissue attaches to the overlying skin by the suspensory ligaments of the breast that pass between the lobes of the mammary glands, modified sweat glands contained within the superficial fascia of the breast.

The superficial fascia of the upper limb contains fat, lymphatics, superficial veins, and cutaneous nerves. In the living body, the superficial veins may be visible through the skin and frequently used for venipuncture. In the cadaver, the superficial veins are not conspicuous.

The order of dissection will be as follows: The skeletal anatomy of the pectoral region will be studied. The skin will be either reflected or removed from the pectoral region and upper limb. The breast will be dissected in female cadaveric specimens. The subcutaneous tissue will either be removed or reflected in a full- or partial-thickness approach. Select superficial veins and cutaneous nerves will be dissected.

### Skeletal Anatomy

Refer to an articulated skeleton or individual bones and identify the following skeletal features.

#### *Scapula and Clavicle*

ATLAS 2.3A, 2.3B, 2.3D

1. Refer to FIGURE 2.5.
2. On a clavicle, identify the **medial (sternal) end** and the **lateral (acromial) end**.
3. Observe that the lateral end of the clavicle articulates with the **acromion of the scapula** to create the **AC joint** laterally.
4. On the anterior aspect of the scapula, identify the **subscapular fossa** bound medially and laterally by the **medial (vertebral)** and **lateral (axillary) borders** respectively.
5. Identify the **coracoid process**, the "beak-like" prominence extending anteriorly lateral to the **suprascapular notch** and medial to the **glenoid fossa**.

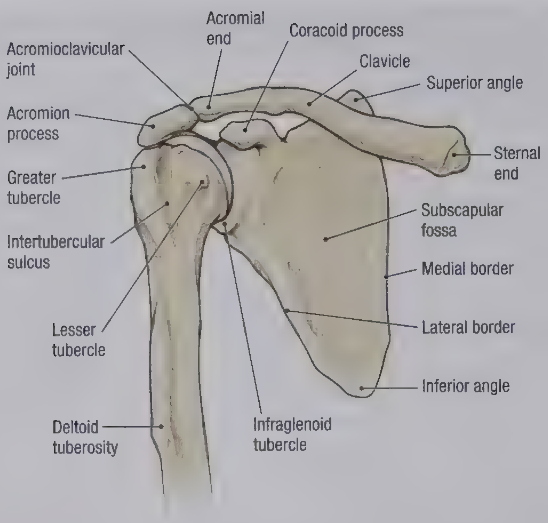

Acromial end
Coracoid process
Acromioclavicular joint
Clavicle
Superior angle
Acromion process
Sternal end
Greater tubercle
Subscapular fossa
Intertubercular sulcus
Medial border
Lateral border
Lesser tubercle
Inferior angle
Deltoid tuberosity
Infraglenoid tubercle

FIGURE 2.5 ■ Skeleton of the right shoulder. Anterior view.

### *Proximal Anterior Humerus*

ATLAS 2.3D, 2.3E

1. Identify the **head of the humerus** on the proximal medial aspect of the bone and observe that it articulates with the glenoid fossa of the scapula to create the glenohumeral (shoulder) joint.
2. Identify the large bony prominence of the **greater tubercle** on the proximal aspect of the humerus laterally.
3. Identify the more anteriorly oriented **lesser tubercle** and note its separation from the greater tubercle by the **intertubercular sulcus (bicipital groove)**.
4. Identify the deltoid tuberosity along the midshaft of the humerus laterally.

## Surface Anatomy

The surface anatomy of the upper limb and pectoral region may be studied on a living subject or on a cadaver. On the cadaver, note that fixation of tissue during embalming may make it difficult to distinguish bone from well-preserved soft tissues in some specimens.

### *Pectoral Region*

ATLAS 2.1A, 2.15, 3.3

1. Refer to FIGURE 2.6.
2. Place the cadaver in the supine position.
3. Beginning at the midline of the neck, palpate the **jugular notch** between the sternal ends of the **clavicles**.
4. On the anterior chest wall, identify and palpate the **sternal angle** at the level of the **2nd costal cartilage**.
5. Palpate inferiorly along the sternum toward the **xiphisternal junction** at the level of the 6th costal cartilage.
6. Palpate bilaterally the **costal margin** toward the midaxillary line.
7. Identify the **nipple** and observe that it is surrounded by the darker tissue of the **areola**. Observe that the nipple is located superficial to the 4th intercostal space.
8. In the female, return to the midline and identify the **intermammary cleft** overlying the body of the sternum between the right and left **breasts**.
9. Palpate from the nipple superolaterally toward the axilla and attempt to identify the location of the **axillary process (tail) of the breast**. *Note that in cadavers with advanced age, it may be difficult to identify the tail of the breast because the mamillary tissue has atrophied.*

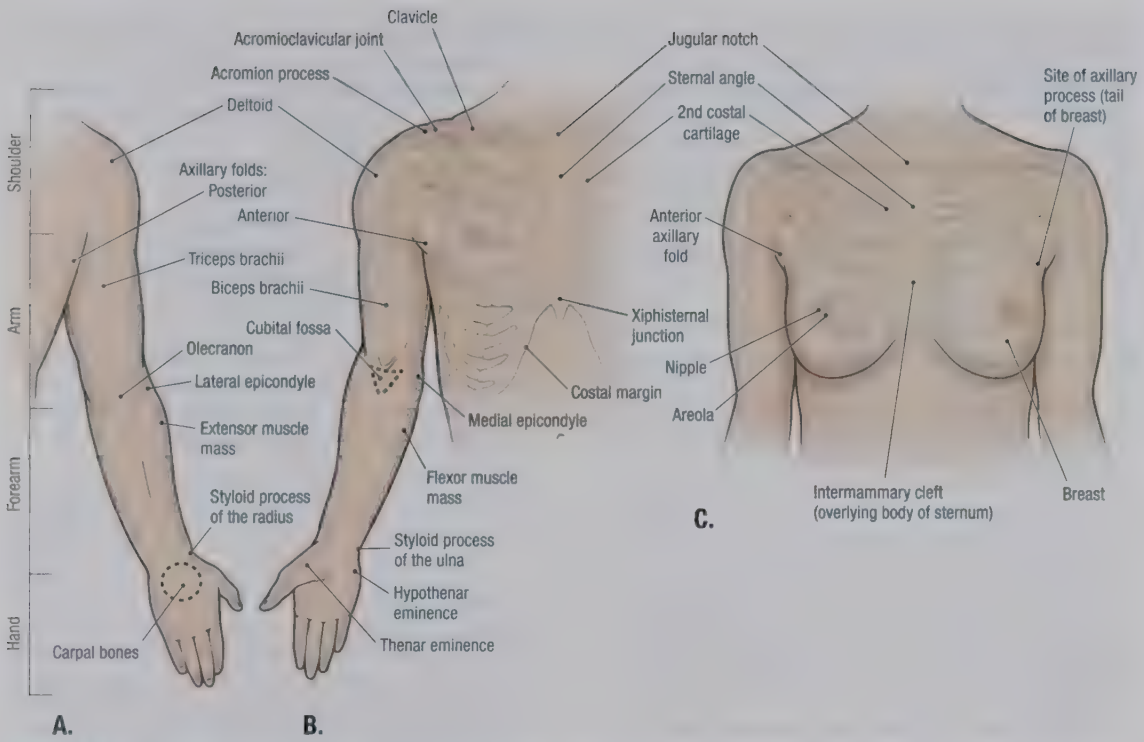

Clavicle
Acromioclavicular joint
Acromion process
Deltoid
Axillary folds:
Posterior
Anterior
Triceps brachii
Biceps brachii
Cubital fossa
Olecranon
Lateral epicondyle
Extensor muscle mass
Styloid process of the radius
Carpal bones
Shoulder
Arm
Forearm
Hand
Medial epicondyle
Flexor muscle mass
Styloid process of the ulna
Hypothenar eminence
Thenar eminence
Jugular notch
Sternal angle
2nd costal cartilage
Anterior axillary fold
Xiphisternal junction
Nipple
Costal margin
Areola
Site of axillary process (tail of breast)
Intermammary cleft (overlying body of sternum)
Breast
A.
B.
C.

FIGURE 2.6 ● **A.** Surface anatomy of the upper limb. Posterior view. **B.** Surface anatomy of upper limb. **C.** Breast. Anterior views.

## *Upper Limb*

ATLAS 2.11D

1. Refer to FIGURE 2.6.
2. Palpate laterally along the clavicle toward the **acromion process** and identify the location of the **AC joint**.
3. Palpate the large muscle mass of the **deltoid muscle** along the lateral shoulder **and** observe that it attaches inferior to the lateral one-third of the clavicle and the acromion process.
4. In the axilla (armpit), palpate the free edges of both the **anterior** and **posterior axillary folds**.
5. On the anterior aspect of the arm, palpate the **biceps brachii muscle** and follow it inferiorly toward the **cubital fossa** anterior to the elbow.
6. On the medial aspect of the cubital fossa, palpate the **medial epicondyle** and the associated **flexor muscle mass** in the anterior forearm.
7. On the lateral aspect of the cubital fossa, palpate the **lateral epicondyle** and the **extensor muscle mass** in the posterior forearm.
8. At the wrist, palpate the **styloid process of the radius** laterally and the **styloid process of the ulna** medially and posteriorly just proximal to the **carpal bones**.
9. In the palm, palpate the **thenar eminence** at the base of the thumb and the **hypothenar eminence** on the medial aspect of the hand.

## Dissection Instructions

***Dissection Note:*** Prior to commencing with skin incisions, decide to perform either a full- or partial-thickness approach and to either reflect or remove the skin from the dissection field. See **Removing the Skin** in the **Introduction Chapter** for descriptions.

Perform the following dissection sequence bilaterally in the male and unilaterally in the female because the breast will be dissected differently on the contralateral side.

### Skin Incisions of the Pectoral Region

ATLAS 2.12; VIDEO 2.2.1 (MALE), VIDEO 2.3.1 (FEMALE)

1. Refer to FIGURE 2.7.
2. Make a midline skin incision from the jugular notch (A) to the xiphisternal junction (C).
3. Elevate a small portion of skin and verify that the skin on the thorax is thinner than the skin on the back, and thus, care must be taken to avoid damaging superficial structures in the region.
4. Make a skin incision from the jugular notch (A) along the clavicle laterally to the acromion process (B).
5. Make an incision from the xiphisternal junction (C) along the costal margin inferolaterally to the midaxillary line (V).
6. Make a transverse skin incision from the middle of the manubrium to the midaxillary line passing around the nipple. The nipple should be kept attached to the superficial fascia and left intact because it is a good superficial landmark for the fourth intercostal space.
7. Make a transverse skin incision from the xiphisternal junction (C) to the midaxillary line.
8. Make a transverse skin incision halfway between the incision line along the clavicle and the incision encircling the nipple.
9. Make an incision beginning on the medial surface of the arm (G) extending superiorly to the axilla.
10. Make an incision from the midpoint of the arm medially (G) around the anterior surface of the arm toward the lateral surface of the arm (F).

***Dissection Note:*** If reflecting the skin, skip steps 11 and 12.

11. Continue the incision from the acromion (B) down the lateral side of the arm to a point approximately halfway down the arm (F). *Note that if the back has previously been dissected, this cut has already been made.*
12. Make a vertical incision along the midaxillary line from the inferior extent of the ribs (V) to the axilla. *Note that if the back has previously been dissected, this cut has already been made.*
13. Beginning in the middle of the thorax, reflect the skin from medial to lateral using either a pair of locking forceps or the buttonhole technique. At any point, the portions of skin may be cut into smaller segments to facilitate removal. *Note that even if a full-thickness reflection is desired, it may prove beneficial to begin with a partial-thickness approach until an appropriate depth of reflection is verified based on visualization of the underlying deep fascia covering the muscles of the region.*
14. If removing the skin, detach the skin along the midaxillary line and lateral aspect of the arm and place it in the tissue container.
15. If reflecting the skin, make an effort to "tuck" the skin from the back underneath the cadaver to provide stability for the portions of skin now being reflected from the thorax and arm. Utilize the uncut sections of skin laterally as hinge points to leave the skin attached along the peripheral aspect of the back.

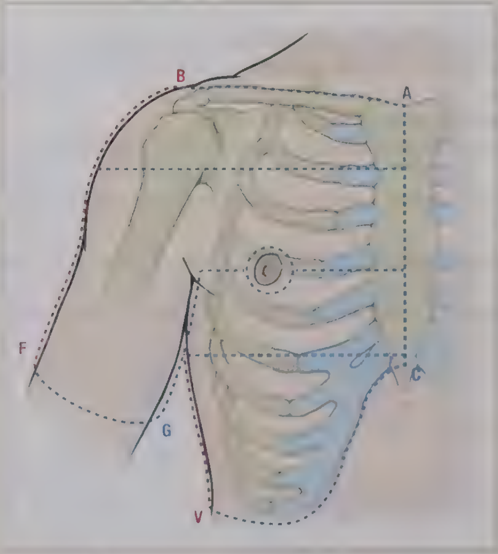


FIGURE 2.7 ● Skin incisions of the pectoral region. Anterior view.

### Breast

ATLAS 3.4A, 3.5A, 3.6A; VIDEO 2.3.2

***Dissection Note:*** Due to the advanced age of some cadavers, it may be difficult to dissect and identify all of the structures listed. Expect the lobes of the gland to be replaced by fat with advanced age. Perform the following dissection sequence on the contralateral side from where the skin was removed.

1. Refer to FIGURE 2.8.
2. Identify the **areola** and the **nipple**.
3. Make a parasagittal (superior to inferior) cut through the nipple to divide the breast into medial and lateral halves and remove the medial half.

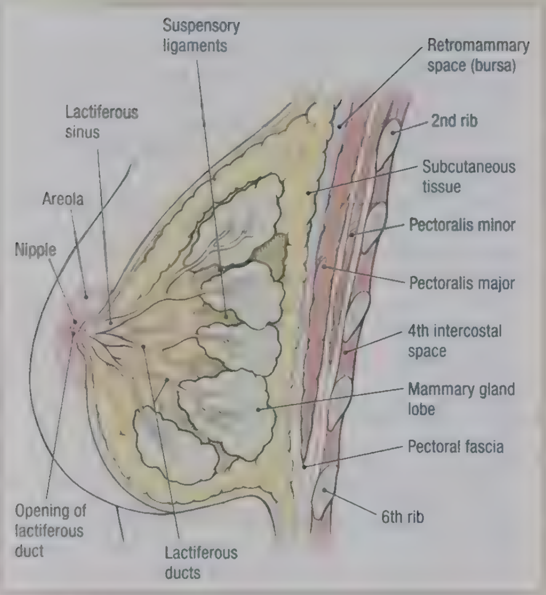

Suspensory ligaments
Retromammary space (bursa)
Lactiferous sinus
2nd rib
Subcutaneous tissue
Areola
Pectoralis minor
Nipple
Pectoralis major
4th intercostal space
Mammary gland lobe
Pectoral fascia
Opening of lactiferous duct
6th rib
Lactiferous ducts

FIGURE 2.8 ● Sagittal section of right breast. Medial view.

4. On the cut edge of the breast, use a probe to dissect through the fat within 3 cm deep to the nipple. Find and clean 1 of the 15 to 20 **lactiferous ducts** converging on the nipple. Identify a **lactiferous sinus**, which is an expanded part of the lactiferous duct.
5. Trace one lactiferous duct to the nipple and attempt to identify its opening.
6. Use the handle of a forceps or a blunt instrument to gently remove the fat from several compartments between the **suspensory ligaments**, the regions that once contained lobes of functional glandular tissue.

CLINICAL CORRELATION

### Breast Cancer and Quadrants

ATLAS 3.4

For descriptive purposes, clinicians divide the breast into four quadrants centered on the nipple. The superolateral (upper outer) quadrant contains a large amount of glandular tissue and is a common site for breast cancers to develop. From this quadrant, an "axillary tail" of breast tissue often extends into the axilla.

In advanced stages of breast cancer, the tumor may invade the underlying pectoralis major muscle and its fascia and fuse to the chest wall. During a physical examination, this fusion can be detected by palpation. As the breast tumor enlarges, it places traction on the suspensory ligaments, resulting in dimpling of the skin overlying the tumor, giving the skin an "orange peel" appearance.

7. Insert your fingers deep to the breast and open the **retromammary space** immediately superficial to the deep fascia. *Note that the normal breast can be easily separated from the underlying deep fascia of the pectoralis major muscle.*
8. Carefully remove the breast from the anterior surface of the pectoralis major muscle with the aid of a scalpel.

## Superficial Fascia of the Pectoral Region

ATLAS 2.13, 2.14; VIDEO 2.2.2

***Dissection Note:*** Dissection of the superficial fascia of the anterior thoracic wall must be performed on both male and female cadavers.

1. Refer to FIGURE 2.9.
2. Identify the **platysma muscle**, a thin but broad muscle of facial expression, which extends inferiorly through the neck into the superficial fascia of the superior thorax.
3. Isolate the platysma from the superficial fascia and reflect the muscle superiorly out of the dissection field superior to the clavicles.
4. Identify **anterior cutaneous nerves** emerging from the intercostal space lateral to the borders of the sternum.
5. If using a partial-thickness skin removal, remove the remaining superficial fascia of the pectoral region proceeding from medial to lateral.
6. Palpate an intercostal space and, near the midaxillary line, identify **lateral cutaneous branches** of the

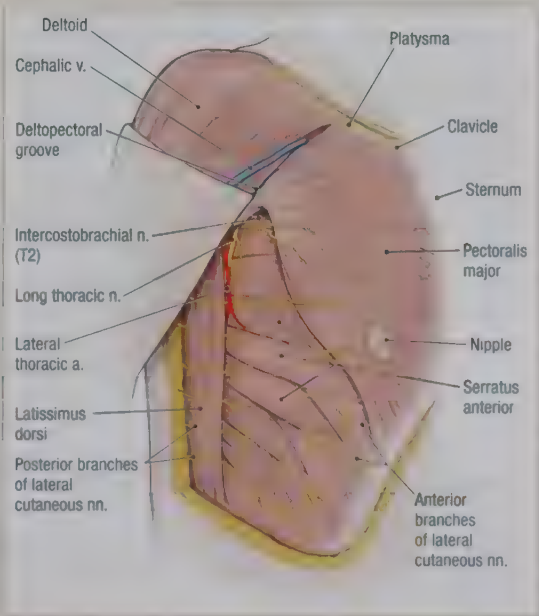

Deltoid
Platysma
Cephalic v.
Deltopectoral groove
Clavicle
Sternum
Intercostobrachial n. (T2)
Pectoralis major
Long thoracic n.
Lateral thoracic a.
Nipple
Serratus anterior
Latissimus dorsi
Posterior branches of lateral cutaneous nn.
Anterior branches of lateral cutaneous nn.

FIGURE 2.9 ● Distribution of lateral cutaneous nerves of the trunk and pectoral region. Anterior view.

intercostal nerves where they leave the intercostal space to enter the superficial fascia. Identify one lateral cutaneous branch (from intercostal space 4, 5, or 6) while the superficial fascia is being removed. If possible, trace its **anterior and posterior branches** for a short distance.

7. Emerging from the 2nd intercostal space, identify the **intercostobrachial nerve**, a somewhat larger lateral cutaneous nerve that supplies the skin of the armpit.
8. Medial to the deltoid muscle, identify and clean a short portion of the **cephalic vein** where it courses in the **deltopectoral groove** between the deltoid and pectoralis major muscles.
9. Observe that near the clavicle, the cephalic vein penetrates the **clavipectoral fascia** within the **deltopectoral triangle** to join the axillary vein. Do not follow the vein deep at this point.
10. Detach the superficial fascia along the midaxillary line and place it in the tissue container, sparing any identified cutaneous nerves.

## Skin Incisions of the Arm and Forearm

ATLAS 2.13; VIDEO 2.2.3

***Dissection Note:*** Prior to commencing with skin incisions, note that the superficial veins and cutaneous nerves are easily damaged in the upper limb if skin incisions are made too deeply. It is thus recommended that along the periphery and anterior surface of the limb, a partial-thickness skinning technique be implemented.

1. Refer to FIGURE 2.10.
2. Make an incision encircling the wrist (E). *Note that the skin is very thin (2 mm) around the wrist—do not cut too deeply.*
3. Make a shallow longitudinal incision on the anterior surface of the upper limb from the midpoint of the arm (G) to the wrist (E), paying particular attention to remain shallow at the cubital fossa.
4. Make an incision around the circumference of the upper limb at a level just distal to the elbow.
5. Beginning from the midline incision, reflect the skin of the upper limb using either a pair of locking forceps or the buttonhole technique. At any point, the portions of skin may be cut into smaller segments to facilitate removal.
6. Remove the skin from the arm and forearm and place it in the tissue container.
7. Because reflecting the skin with portions still attached will block views of the underlying anatomy, it is recommended to keep the removed portions of skin in large pieces, which may be used later to wrap the limb post dissection to prevent desiccation.

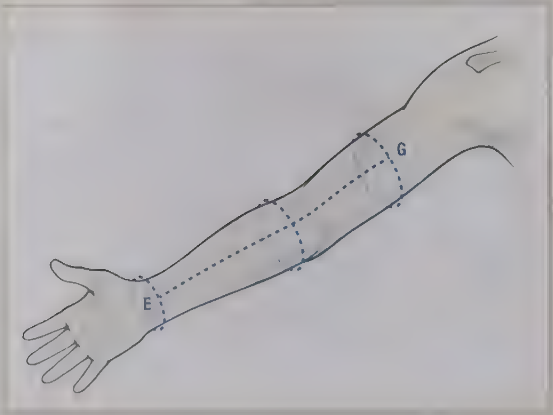


FIGURE 2.10 ■ Skin incisions of the upper limb. Anterior view.

## Superficial Veins of the Upper Limb

ATLAS 2.10, 2.11A; VIDEO 2.2.4

1. Refer to FIGURE 2.11.
2. With the body lying supine, rotate the upper limb or flex the elbow to increase visibility of the upper limb structures and use blunt dissection with a probe, forceps, or dissecting scissors to demonstrate the superficial veins of the arm and forearm.
3. Beginning near the wrist in the posterior forearm, demonstrate the **basilic vein** and the **cephalic vein**, but do not follow them distally because the superficial veins of the dorsum of the hand will be studied when the hand is dissected.
4. Use blunt dissection to follow the cephalic and basilic veins proximally freeing them from the surrounding fat and connective tissue. *Note that it may be useful to abduct the upper limb to 45° if possible and to have your dissection partner hold it in the abducted position.*
5. Demonstrate that the cephalic and basilic veins are joined across the cubital fossa by the **median cubital vein**. *Note that the venous pattern in this region can be quite variable and should be observed on other cadavers as an example of anatomical variation.*
6. Follow the cephalic vein proximally into the pectoral region where it courses in the **deltopectoral groove**.
7. Follow the basilic vein proximally and note that a few centimeters above the medial epicondyle, it pierces the deep fascia to join the deep veins. Do not follow it into the axilla at this time.
8. Use a probe to elevate the superficial veins and note that several **perforating veins** penetrate the deep fascia to connect the superficial and deep veins of the upper limb.

## Cutaneous Nerves and Upper Limb Fascia

ATLAS 2.5, 2.13; VIDEO 2.2.5

1. Refer to FIGURE 2.11.
2. Familiarize yourself with the course and distribution of the **cutaneous nerves of the arm** and **forearm**.

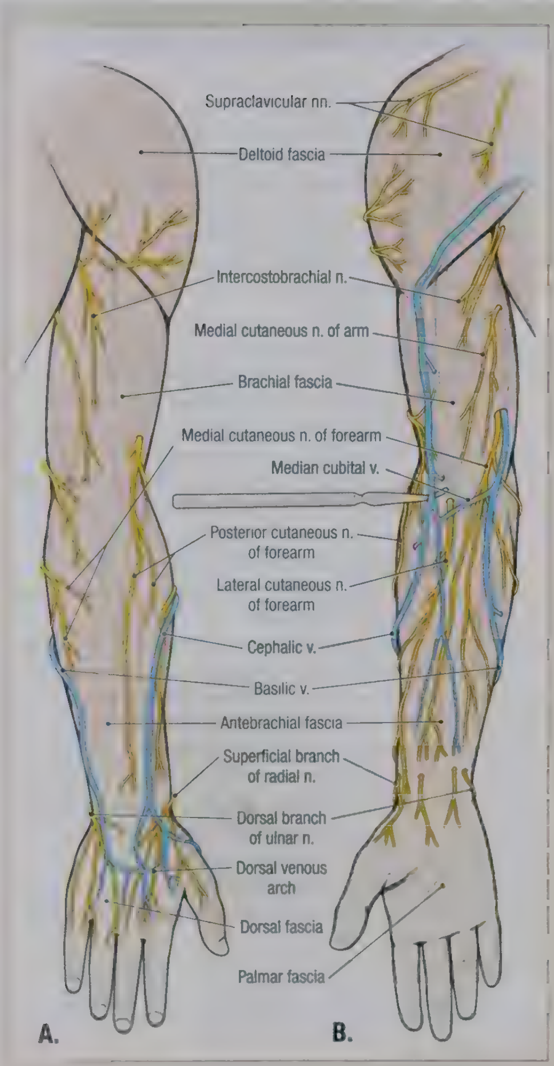

Supraclavicular nn.
Deltoid fascia
Intercostobrachial n.
Medial cutaneous n. of arm
Brachial fascia
Medial cutaneous n. of forearm
Median cubital v.
Posterior cutaneous n. of forearm
Lateral cutaneous n. of forearm
Cephalic v.
Basilic v.
Antebrachial fascia
Superficial branch of radial n.
Dorsal branch of ulnar n.
Dorsal venous arch
Dorsal fascia
Palmar fascia
A.
B.

FIGURE 2.11 ● Superficial veins and cutaneous nerves of the upper limb. **A.** Posterior view. **B.** Anterior view.

3. Identify the **lateral cutaneous nerve of the forearm** within the superficial fascia anterior to the lateral epicondyle of the humerus lateral to the distal tendon of the biceps brachii muscle.
4. Clean the lateral cutaneous nerve of the forearm and observe its close relationship to the cephalic and median cubital veins in the superficial fascia near the cubital fossa.
5. On the medial side of the biceps brachii tendon, identify the **medial cutaneous nerve of the forearm**, noting its close relationship to the basilic vein.
6. Near the wrist, identify and clean the **superficial branch of the radial nerve** in the superficial fascia near the styloid process of the radius for 2 or 3 cm. Make an effort to not disrupt the nearby structures in the anatomical snuffbox.
7. On the medial aspect of the wrist and hand, identify and clean the **dorsal branch of the ulnar nerve** in the superficial fascia near the styloid process of the ulna for 2 or 3 cm.
8. Remove all remaining superficial fascia from the arm and forearm preserving the dissected superficial veins and nerves. Do not disturb the deep fascia overlying the muscles. Place the superficial fascia in the tissue container.
9. Examine the visible **deep (investing) fascia** of the upper limb and observe that it extends from the shoulder to the wrist. *Note that the deep fascia continues into the hand all the way to the finger tips, with* ***palmar fascia*** *on the anterior (ventral) surface of the hand and* ***dorsal fascia of the hand*** *on the posterior (dorsal) surface of the hand.*
10. Identify the **brachial fascia** in the arm and observe how it subdivides the region into anterior and posterior compartments by connecting to the medial and lateral intermuscular septa, which dive deep to attach to the humerus.
11. Identify the **antebrachial fascia** in the forearm. Observe how the antebrachial fascia is comparatively thicker and tougher than the brachial fascia.

## Dissection Follow-up

1. Review the location and parts of the breast.
2. Familiarize yourself with the vascular supply and lymphatic drainage of the breast.
3. Trace the course of the superficial veins of the upper limb from distal to proximal noting important access sites for venipuncture.
4. Review the path of the cutaneous nerves of the upper limb.
5. Review and name the various components of the deep fascia of the upper limb.
6. Replace the reflected portions of skin back to anatomical position.

# MUSCLES OF THE PECTORAL REGION

## Dissection Overview

There are four muscles in the pectoral region: pectoralis major, pectoralis minor, subclavius, and the serratus anterior. The muscles of the pectoral region, also classified as anterior axioappendicular muscles, attach between the axial and appendicular skeletons and provide movement and stability to the upper limb. The serratus anterior will be visible following reflection of the pectoralis major; however, it will not be dissected at this time.

The order of dissection will be as follows: The pectoralis major muscle will be studied and reflected. The pectoralis minor muscle and clavipectoral fascia will be studied. The subclavius muscle will be identified. The pectoralis minor muscle will be reflected, and the branches of the thoracoacromial artery will be dissected.

## Dissection Instructions

### Pectoralis Major

ATLAS 2.14, 2.18A; VIDEO 2.4.1

1. Refer to FIGURE 2.12.
2. Clean the superficial surface of the **pectoralis major muscle** and clearly define its borders. *Note that the deep fascia on the superficial and deep surfaces of the pectoralis major muscle is called pectoral fascia and that it is continuous with the axillary fascia forming the base of the axilla.*
3. Identify the **clavicular head of the pectoralis major** attaching along the clavicle and the **sternocostal head of the pectoralis major** attaching along the body of the sternum and costal cartilage. Observe that the juncture of these two heads is at the sternoclavicular joint.
4. Review the attachments and actions of the pectoralis major muscle (see **TABLE 2.2**).
5. Identify the **deltopectoral triangle** located between the superior border of the clavicular head of the pectoralis major muscle and the anterior border of the deltoid muscle near the clavicle. The apex of the deltopectoral triangle narrows to form the **deltopectoral groove**, a depression between the pectoralis major and the deltoid muscles.
6. Using blunt dissection, follow the **cephalic vein** from the arm to the deltopectoral triangle where the vein penetrates the deep fascia to enter the axilla.
7. Clean the anterior surface of the deltoid muscle but make an effort to preserve the cephalic vein in subsequent steps of this dissection.
8. To prepare the pectoralis major muscle for reflection, relax the sternal head of the pectoralis major muscle by flexing and adducting the arm or by placing a dissection block under the ipsilateral shoulder.
9. Use blunt dissection deep to the inferior border of the pectoralis major muscle and create a space between the pectoralis major and its surrounding pectoral fascia and the underlying pectoralis minor and its surrounding clavipectoral fascia.
10. Beginning at the inferior border of the muscle, detach the sternocostal head of the pectoralis major

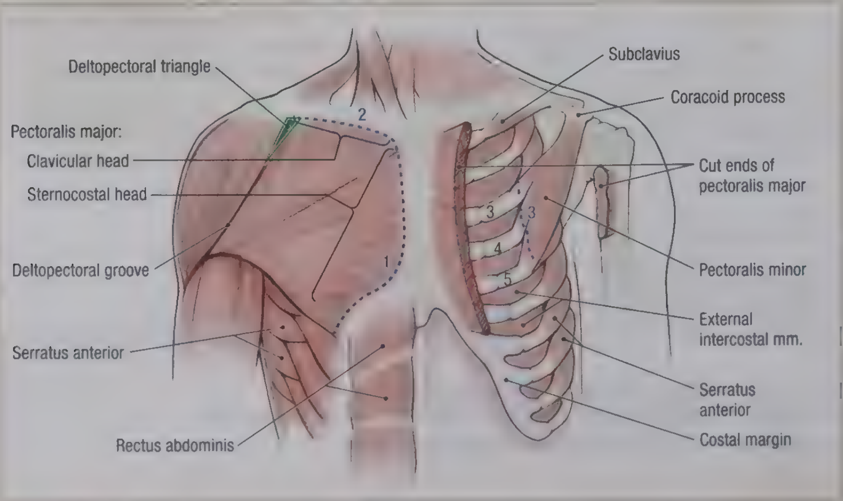


FIGURE 2.12 • Superficial (*right*) and deep (*left*) dissections of the pectoral region. Anterior view.

muscle from its attachment to the costal cartilages and sternum (**Cut 1**).

11. Working from inferior to superior, insert your fingers deep to the clavicular head and palpate the **medial and lateral pectoral nerves and vessels** inserting on the deep surface of the pectoralis major muscle. *Note that the medial and lateral pectoral nerves are named according to the cord of the brachial plexus from which they arise and not their relative anatomical locations.*
12. Detach the clavicular head of the pectoralis major muscle as close to the clavicle as possible (**Cut 2**). The **lateral pectoral nerve** and the **pectoral branch of the thoracoacromial artery** enter the deep surface of the clavicular head and are easily cut during detachment of the clavicular head if care is not taken.
13. Gently reflect the pectoralis major muscle laterally, leaving it attached to the humerus while preserving the nerves and vessels that enter its deep surface. Do not yet fully reflect the muscle or the neurovascular structures will be torn.
14. Identify the **clavipectoral fascia** immediately deep to the pectoralis major muscle. Superiorly, the clavipectoral fascia is attached to the clavicle and lies both superficial and deep to the subclavius and pectoralis minor muscles. Inferiorly, the clavipectoral fascia is attached to the axillary fascia.

## Pectoralis Minor and Thoracoacromial Artery

ATLAS 2.18B, 2.20; VIDEO 2.4.2

1. Refer to FIGURE 2.12.
2. Identify the **pectoralis minor muscle**.
3. Observe that the cephalic vein passes from superficial to deep on the medial side of the pectoralis minor muscle through the costocoracoid membrane (part of the clavipectoral fascia).
4. Locate the **medial pectoral nerve** where it pierces the pectoralis minor muscle and follow it to where it enters the deep surface of the pectoralis major muscle.
5. Clean the surface of the pectoralis minor muscle and clearly define its borders sparing the medial pectoral nerve.
6. Scrape remaining portions of pectoralis major muscle off the clavicle.
7. Deep to the clavicle, identify and clean the visible portions of the **subclavius muscle**.
8. Review the attachments and actions of the pectoralis minor and subclavius muscles (see **TABLE 2.2**).
9. Use scissors to detach the pectoralis minor muscle from its inferior attachments on ribs 3 to 5 (**Cut 3**).
10. Reflect the pectoralis minor muscle superiorly, leaving it attached to the coracoid process of the scapula.
11. Refer to FIGURE 2.13.
12. Medial to the reflected pectoralis minor muscle, identify branches of the **thoracoacromial artery** and the lateral pectoral nerve. Note these neurovascular structures also pass through the costocoracoid membrane.
13. Identify and clean the branches of the thoracoacromial artery beginning with the **pectoral branch**. The pectoral branch is typically the largest of the branches and descends between the pectoralis major and pectoralis minor muscles.
14. The **deltoid branch** courses laterally in the deltopectoral groove between the deltoid muscle and pectoralis major muscle and accompanies the cephalic vein.
15. The **acromial branch** courses superior to the coracoid process toward the acromion.
16. The **clavicular branch** courses medially to supply the subclavius muscle and the sternoclavicular joint.

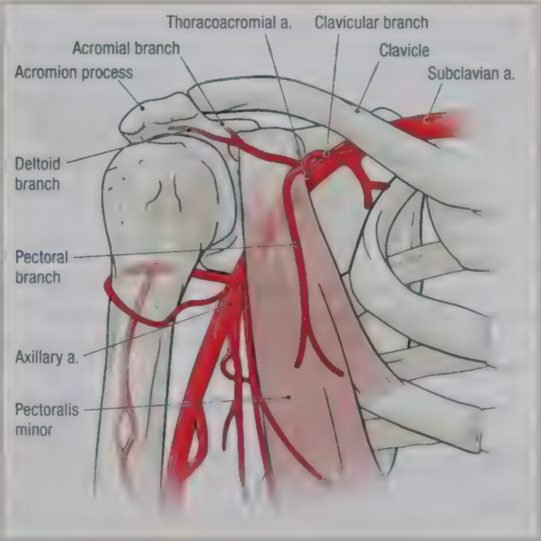


FIGURE 2.13 ● Arterial supply of the pectoral region isolated. Anterior view.

## Dissection Follow-up

1. Review the attachments, actions, and innervations of the pectoralis major, pectoralis minor, and subclavius muscles in **TABLE 2.2**.
2. Review the relationship of the clavipectoral and pectoral fascial layers to the muscles, vessels, and nerves of this region and its role in supporting the base of the axilla.
3. Identify the branches of the thoracoacromial artery and the structures supplied by each.
4. Replace the pectoral muscles into their correct anatomical positions.

**TABLE 2.2** **Muscles of the Pectoral Region**

| *Muscle* | *Medial Attachments* | *Lateral Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Pectoralis major | Medial half of clavicle, sternum, costal cartilages 1–7 | Lateral lip of intertubercular sulcus | Medially rotates, flexes, and adducts the humerus | Medial and lateral pectoral nn. |
| Pectoralis minor | Ribs 3–5 | Coracoid process of scapula | Anteriorly tilts and depresses the scapula | Medial pectoral n. |
| Subclavius | Rib 1 | Clavicle | Depresses the clavicle and stabilizes the SC joint | Nerve to subclavius |

Abbreviations: n., nerve; nn., nerves; SC, sternoclavicular joint.

# AXILLA

## Dissection Overview

The axilla (the "armpit") is the region between the pectoral muscles, the scapula, the arm, and the thoracic wall. Due to its central location, the axilla is a key region of passage for vessels and nerves coursing between the root of the neck, the thorax, and the upper limb. The contents of the axilla are the axillary sheath, the brachial plexus, the axillary vessels and their branches, lymph nodes and lymphatic vessels, portions of three muscles, and a considerable amount of fat and connective tissue as shown in FIGURE 2.14.

The brachial plexus is a network of nerves innervating the upper limb originating from spinal cord levels C5–T1, which begins superior to the clavicle, courses through the apex of the axilla, and then passes inferolaterally toward the base of the axilla where its terminal branches arise. Only the infraclavicular part of the brachial plexus (cords and branches) will be dissected at this time. The supraclavicular part (roots, trunks, and divisions) will be dissected with the neck.

The order of dissection will be as follows: The axillary vein and its tributaries will be removed. The branches of the axillary artery will be dissected. The brachial plexus will be studied.

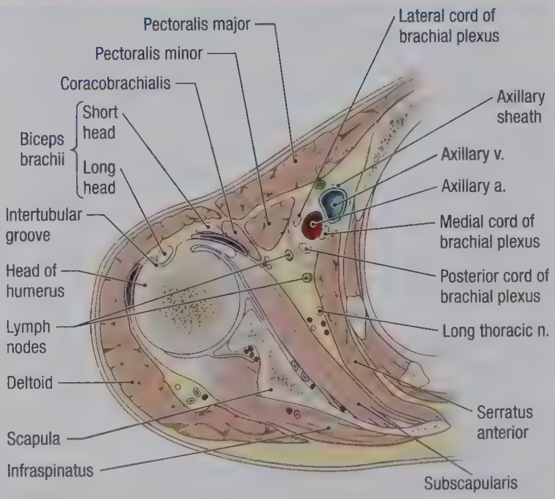

Pectoralis major
Pectoralis minor
Coracobrachialis
Biceps brachii
Short head
Long head
Intertubular groove
Head of humerus
Lymph nodes
Deltoid
Scapula
Infraspinatus
Lateral cord of brachial plexus
Axillary sheath
Axillary v.
Axillary a.
Medial cord of brachial plexus
Posterior cord of brachial plexus
Long thoracic n.
Serratus anterior
Subscapularis

FIGURE 2.14 ● Axial section through right shoulder and axilla. Inferior view.

## Dissection Instructions

### Axilla

ATLAS 2.22, 2.23; VIDEO 2.5.1

1. Refer to FIGURE 2.15.
2. Review the **walls and boundaries of the axilla** on the cadaver beginning superiorly at the **apex of the axilla**.
3. The apex of the axilla is bounded by the clavicle anteriorly, the superior border of the scapula posteriorly, and the first rib medially.
4. The **base of the axilla** is the skin and fascia of the armpit.
5. The **anterior wall of the axilla** is defined by the anterior axillary fold containing the pectoralis major muscle, part of the pectoralis minor muscle, and the clavipectoral fascia.
6. The **posterior wall of the axilla** is defined by the posterior axillary fold containing the teres major and latissimus dorsi muscles inferiorly and the subscapularis muscle covering the anterior surface of the scapula.
7. The **medial wall of the axilla** is the upper portion of the lateral thoracic wall and the serratus anterior muscle.
8. The **lateral wall of the axilla** is the intertubercular sulcus of the humerus.
9. Reflect the pectoralis major muscle laterally and the pectoralis minor muscle superiorly.

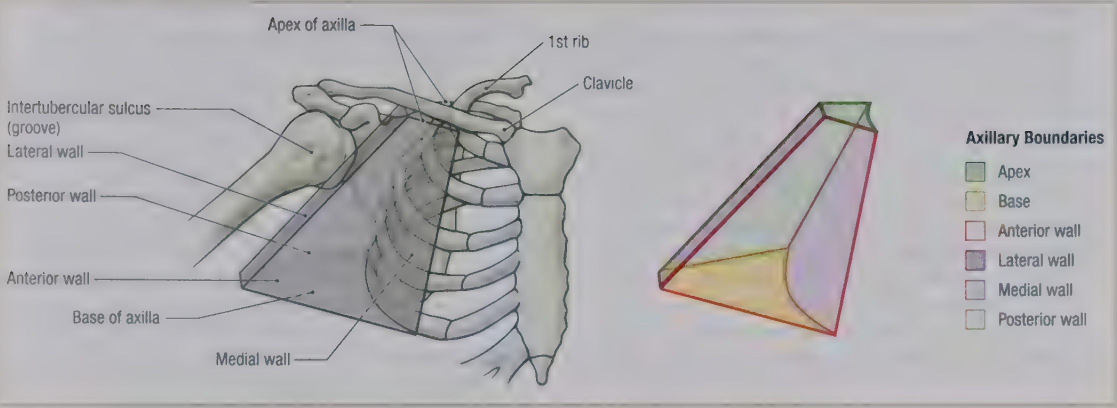

Apex of axilla
1st rib
Clavicle
Intertubercular sulcus (groove)
Lateral wall
Posterior wall
Anterior wall
Base of axilla
Medial wall
Axillary Boundaries
Apex
Base
Anterior wall
Lateral wall
Medial wall
Posterior wall

FIGURE 2.15 ● Walls and boundaries of the axilla. Anterior view.

10. Abduct the upper limb to approximately 45°.
11. Observe that the axilla contains a large amount of axillary fat to protect the contents of the region while allowing for mobility of the upper limb.
12. Within the axillary fat, identify the **axillary sheath**, a thin layer of connective tissue surrounding the axillary vessels and components of the brachial plexus. The axillary sheath extends from the lateral border of the first rib to the inferior border of the teres major muscle.
13. Use scissors or blunt dissection to open the anterior surface of the axillary sheath.
14. Identify the **axillary vein** and observe that it is formed near the lateral border of the teres major muscle by the joining of the brachial and basilic veins.
15. Follow the axillary vein medially to where it ends near the lateral border of the first rib at the point where the cephalic vein drains into it. *Note that medial to the cephalic veins point of drainage, the axillary vein changes names to the subclavian vein.*
16. To increase visibility of the arteries and nerves in the axilla, the axillary vein must be removed.
17. Cut the axillary vein near the lateral border of the first rib lateral to the point of drainage of the cephalic vein and reflect it laterally.
18. While reflecting the axillary vein laterally, use blunt dissection to separate it from the structures that lie posterior to it (axillary artery and brachial plexus), cutting the small tributary veins draining into it along its length.
19. Cut the axillary vein near the inferior border of the teres major muscle and remove it from the dissection field.
20. As the dissection proceeds, continue to remove the veins within the axilla while preserving the accompanying arteries.
21. Remove any lymph nodes in the region associated with the veins.

## Axillary Artery

ATLAS 2.21, 2.26, 2.27; VIDEO 2.5.2

***Dissection Note:*** The axillary artery is surrounded by the brachial plexus, which must be retracted and preserved during dissection of the axillary artery and its branches.

1. Refer to FIGURE 2.16.
2. Identify the **axillary artery** within the axilla. The axillary artery begins at the lateral border of the first rib as the continuation of the **subclavian artery** and ends at the inferior border of the teres major muscle where it becomes the **brachial artery**.

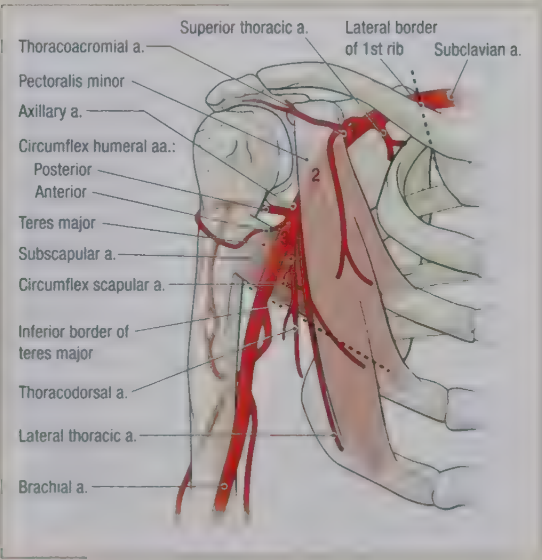

Superior thoracic a.
Lateral border of 1st rib
Subclavian a.
Thoracoacromial a.
Pectoralis minor
Axillary a.
Circumflex humeral aa.:
Posterior
Anterior
Teres major
Subscapular a.
Circumflex scapular a.
Inferior border of teres major
Thoracodorsal a.
Lateral thoracic a.
Brachial a.
2

FIGURE 2.16 ● Branches of the axillary artery isolated. Anterior view.

3. Using the pectoralis minor muscle as a landmark, identify the **three parts of the axillary artery**.
4. Identify the **first part of the axillary artery** between the lateral border of the first rib and the medial border of the pectoralis minor muscle.
5. Identify the **second part of the axillary artery** posterior to the pectoralis minor muscle and the **third part** between the lateral border of the pectoralis minor muscle and the inferior border of the teres major muscle. *Note that the branching pattern of the axillary artery may vary from that which is commonly illustrated. If the pattern is different in your specimen, understand that the branches are named according to their region of distribution rather than by their point of origin.*
6. The first part of the axillary artery has one branch. Identify and clean the **superior thoracic artery**, which arises near the apex of the axilla to supply blood to the first and second intercostal spaces.
7. The second part of the axillary artery has two branches: the **thoracoacromial artery** and the **lateral thoracic artery**. Identify the thoracoacromial artery near the medial border of the pectoralis minor and review its branches previously dissected: the pectoral, acromial, deltoid, and clavicular.
8. Identify and clean the **lateral thoracic artery**, which typically branches off the axillary artery near the lateral border of the pectoralis minor muscle, although it may arise from the subscapular or thoracoacromial arteries, to supply the pectoral muscles, the serratus anterior muscle, the axillary lymph nodes, and the lateral thoracic wall. *Note that in females, the lateral thoracic artery also supplies the lateral portion of the breast and is often referred to as the lateral mammary artery.*
9. The third part of the axillary artery has three branches: the **subscapular artery**, the **posterior circumflex humeral artery**, and the **anterior circumflex humeral artery**.
10. Identify and clean the **subscapular artery**, the largest branch of the axillary artery.
11. Identify the terminal branches of the subscapular artery, the **circumflex scapular artery** (supplies muscles on the posterior surface of the scapula), and the **thoracodorsal artery** (supplies the latissimus dorsi muscle). *Note that the subscapular artery also gives several unnamed muscular branches and may be the origin of the lateral thoracic artery.*
12. Identify and clean the **anterior and posterior circumflex humeral arteries**, which arise from the lateral surface of the axillary artery distal to the origin of the subscapular artery. The circumflex humeral arteries supply the deltoid muscle and anastomose around the surgical neck of the humerus and may arise from a short common trunk.
13. Observe that the **posterior circumflex humeral artery** is typically the larger of the two circumflex humeral arteries.
14. Follow the posterior circumflex humeral artery posterior to the surgical neck of the humerus and observe its close proximity to the axillary nerve as these structures pass through the quadrangular space.
15. Follow the **anterior circumflex humeral artery** for a short distance and observe that this vessel courses around the anterior surface of the humerus at the surgical neck deep to the tendon of the long head of the biceps brachii muscle.

## Brachial Plexus

ATLAS 2.25, 2.26, 2.28; VIDEO 2.5.3

***Dissection Note:*** The branching pattern of the nerves of the brachial plexus varies somewhat between individuals. Use the peripheral relationships of the nerves (their region of distribution or a point of exit from the axilla) for positive identification. Minimal force is required to separate the cords and terminal branches of the brachial plexus, and much of the dissection can be done gently with blunt dissection.

1. Refer to FIGURE 2.17.
2. Follow the pectoralis minor deep into the axilla and identify the location of the coracoid process.
3. Observe that the coracoid process serves as the attachment for three muscles: pectoralis minor, **coracobrachialis**, and the **short head of the biceps brachii**.
4. Using the pectoralis minor as a landmark, identify the second part of the axillary artery and the three

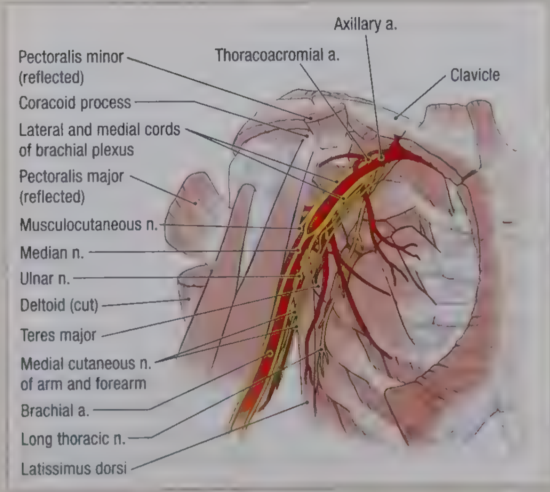


FIGURE 2.17 ■ Infraclavicular (axillary) portion of the brachial plexus. Anterior view.

**cords of the brachial plexus** (lateral, medial, and posterior), named according to their relationship to the axillary artery.

5. Identify the **musculocutaneous nerve** where it pierces the coracobrachialis muscle. *Note that the musculocutaneous nerve is the most lateral terminal branch of the brachial plexus.*
6. Use blunt dissection to follow the musculocutaneous nerve proximally to the **lateral cord of the brachial plexus**.
7. Observe that the lateral cord gives rise to one other large branch, the **lateral root of the median nerve**. Follow the lateral root distally and identify the **median nerve**.
8. Trace the **medial root of the median nerve** proximally to the **medial cord** resting against the medial aspect of the axillary artery.
9. Identify the **ulnar nerve**, the other terminal branch arising from the medial cord.
10. Use the cadaver or an illustration to observe that the three **terminal branches** you have just identified (musculocutaneous nerve, median nerve, and ulnar nerve) form a rough letter "M" anterior to the third part of the axillary artery.
11. Trace the **medial** and **lateral pectoral nerves** from the reflected pectoral muscles to their origins from the medial and lateral cords, respectively. *Note that the pectoral nerves are named for their origins from the medial and lateral cords, not for their relationship to each other relative to the median plane.*
12. Identify the **medial cutaneous nerve of the arm** and the **medial cutaneous nerve of the forearm** originating from the medial cord proximal to the ulnar nerve. Use blunt dissection to trace these nerves a short distance into the arm.
13. Refer to FIGURE 2.18.
14. Gently retract the axillary artery, the lateral cord, and the medial cord superiorly to expose the **posterior cord** of the brachial plexus.
15. Observe that the posterior cord gives rise to the **upper and lower subscapular nerves** and the **thoracodorsal nerve** prior to terminating as the **axillary** and **radial nerves**.
16. Use blunt dissection to clean the **axillary nerve**. Recall that the axillary nerve passed through the quadrangular space with the posterior circumflex humeral artery to reach the deltoid and teres minor muscles.
17. Use blunt dissection to clean the **radial nerve**. Confirm that the radial nerve leaves the axilla by passing anterior to the latissimus dorsi and teres major muscles and that it runs toward the triceps muscle in the posterior compartment of the arm.
18. Observe that the radial nerve is larger than the axillary nerve and recall that it coursed within the radial groove near the midshaft of the humerus.

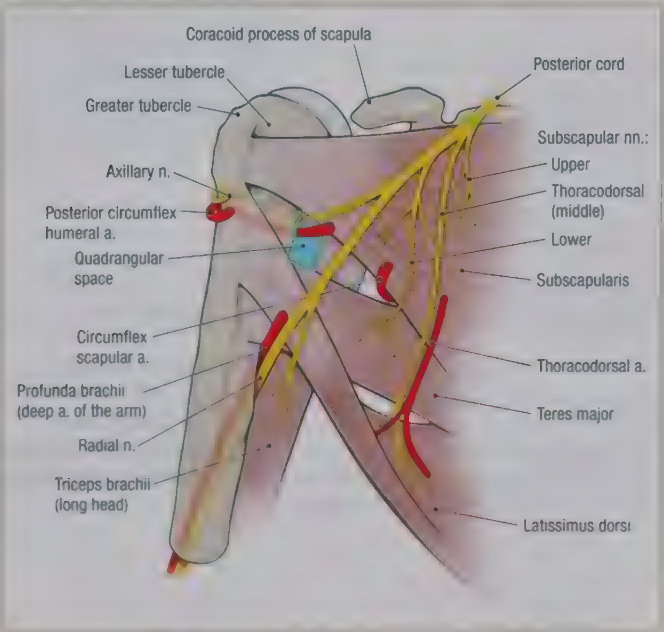

Coracoid process of scapula
Lesser tubercle
Greater tubercle
Posterior cord
Subscapular nn.:
Upper
Thoracodorsal (middle)
Lower
Axillary n.
Posterior circumflex humeral a.
Quadrangular space
Subscapularis
Circumflex scapular a.
Profunda brachii (deep a. of the arm)
Radial n.
Triceps brachii (long head)
Thoracodorsal a.
Teres major
Latissimus dorsi

FIGURE 2.18 ▪ Posterior cord of the brachial plexus and posterior wall of the axilla. Anterior view.

*Note that the radial nerve is the only motor and sensory nerve to the posterior compartments of the upper limb.*

19. Beginning centrally, identify and isolate the **thoracodorsal nerve** arising off the posterior cord and trace it inferiorly to the latissimus dorsi muscle.
20. Distal to the branch point of the thoracodorsal nerve, identify and isolate the **lower subscapular nerve** and follow it a short distance toward the subscapularis and teres major muscles.
21. Proximal to the thoracodorsal nerve, identify the **upper subscapular nerve**, which is the first of three branches from the posterior cord and the most difficult to identify. Trace the upper subscapular nerve distally to the subscapularis muscle. *Note that all three branches of the posterior cord run in the loose connective tissue on the anterior surface of the subscapularis muscle.*
22. Identify the three muscles forming the posterior wall of the axilla: the **latissimus dorsi**, the **teres major**, and the **subscapularis**.
23. Observe that the subscapularis covers the anterior surface of the scapula and recall that it is a member of the **rotator cuff group of muscles**.
24. Review the attachments and actions of the subscapularis muscle (see **TABLE 2.3**).
25. Identify the **serratus anterior muscle** and recall that it forms the medial wall of the axilla.
26. Slide your hand into the axilla and verify that the serratus anterior attaches onto the medial border of the scapula. With your palm against the subscapularis muscle, the back of your hand is against the serratus anterior muscle.
27. On the superficial surface of the serratus anterior muscle, identify and clean the **long thoracic nerve** coursing vertically and observe that it sends multiple branches to the serratus anterior muscle.
28. Follow the long thoracic nerve superiorly toward the apex of the axilla as far as possible and confirm that the long thoracic nerve does not arise from one of the three cords of the brachial plexus like the other nerves in the region and rather arises from the roots of the brachial plexus from vertebral levels C5–C7.
29. Clean the surface of the serratus anterior muscle paying attention not to disrupt the long thoracic nerve.
30. Review the actions and innervations of the serratus anterior muscle (see **TABLE 2.3**).

**CLINICAL CORRELATION**

**Nerve Injuries (Long Thoracic, Thoracodorsal, and Axillary Nerve Neuropathies)**

ATLAS 2.4, 2.29, 2.44B

The long thoracic nerve is vulnerable to stab wounds and surgical injury during mastectomy. Injury of the long thoracic nerve affects the serratus anterior muscle. When a patient with paralysis of the serratus anterior muscle is asked to push with both hands against a wall, the medial border of the scapula protrudes on the affected side, a condition known as "winged scapula."

The thoracodorsal nerve is vulnerable to compression injuries and surgical trauma during mastectomy and/or axillary dissection (removal of the lymph nodes). Injury of the thoracodorsal nerve affects the latissimus dorsi muscle, resulting in a weakened ability to extend, adduct, and medially rotate the arm.

The axillary nerve courses around the surgical neck of the humerus and may be injured during a humeral fracture or during an inferior dislocation of the shoulder joint. Injury of the axillary nerve affects the deltoid and teres minor muscles, resulting in a weakened ability to abduct and laterally rotate the arm.

## Dissection Follow-up

1. Review the boundaries and major contents of the axilla.
2. Review the relationship of the three parts of the axillary artery to the pectoralis minor muscle and name the arterial branches of each part.
3. Review the subdivisions of the brachial plexus focusing on the orientation of the infraclavicular portion within the axilla.
4. Review the target structures of each terminal branch of the brachial plexus.
5. Review the movements of the groups of muscles acting on the scapula in **TABLE 2.3**.
6. Replace the pectoralis major and pectoralis minor muscles into their correct anatomical positions.
7. Examine other cadavers to gain an appreciation of variations in the branching pattern of arteries and nerves.
8. Familiarize yourself with the lymphatic drainage of the axilla.

**TABLE 2.3 | Muscles of the Axilla**

MEDIAL WALL

| *Muscle* | *Medial Attachments* | *Lateral Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Serratus anterior | Anterior surface of the medial border of the scapula | Ribs 1–9 lateral parts | Rotates glenoid cavity superiorly and protracts the scapula | Long thoracic n. |

POSTERIOR WALL

| *Muscle* | *Medial Attachments* | *Lateral Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Subscapularis | Subscapular fossa | Lesser tubercle of the humerus | Medially rotates the humerus | Upper and lower subscapular nn. |
| Latissimus dorsi | Thoracolumbar fascia, iliac crest | Intertubercular groove (floor) | Extends, adducts, and medially rotates the humerus | Thoracodorsal n. |
| Teres major | Inferior angle of the scapula | Medial lip of the intertubercular sulcus | Adducts and medially rotates the humerus | Lower subscapular n. |

Abbreviations: n., nerve; nn., nerves.

# ARM (BRACHIUM) AND CUBITAL FOSSA

## Dissection Overview

The brachial fascia (deep fascia of the arm) is a sleeve of tough connective tissue investing the arm. Brachial fascia is continuous at its proximal end with the pectoral fascia, the axillary fascia, and the deep fascia covering the deltoid and latissimus dorsi muscles. Distally, the brachial fascia is continuous with the antebrachial fascia (deep fascia of the forearm). The brachial fascia is connected to the medial and lateral sides of the humerus by intermuscular septa creating an anterior (flexor) compartment and a posterior (extensor) compartment for the muscles of the arm as shown in FIGURE 2.19. The anterior compartment contains three muscles (biceps brachii, brachialis, and coracobrachialis), whereas the posterior compartment predominately contains the triceps brachii muscle along with the small anconeus muscle distally.

The cubital fossa is the depression on the anterior surface of the elbow. The cubital fossa is a clinically important region because it contains the brachial artery and accompanying veins, the median nerve, and the superficial veins commonly used for venipuncture.

The order of dissection will be as follows: The skeletal anatomy of the elbow will be studied. The anterior compartment of the arm will be opened, and its contents will be studied. Nerves and blood vessels will then be traced from the axilla through the arm to the cubital fossa.

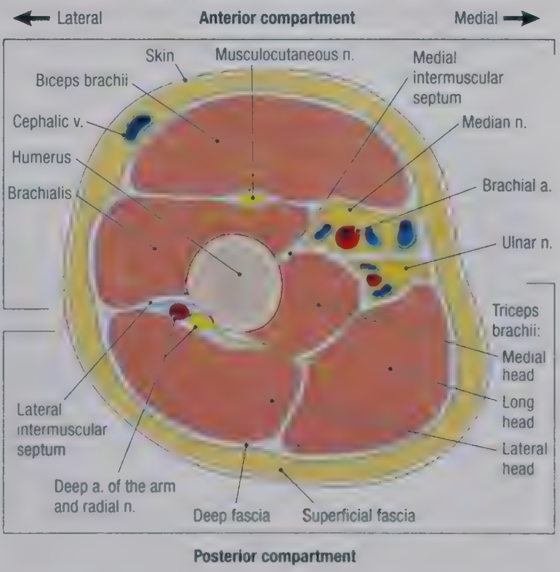

← Lateral
Anterior compartment
Medial →
Skin
Musculocutaneous n.
Medial intermuscular septum
Biceps brachii
Cephalic v.
Median n.
Humerus
Brachialis
Brachial a.
Ulnar n.
Triceps brachii:
Medial head
Long head
Lateral head
Lateral intermuscular septum
Deep a. of the arm and radial n.
Deep fascia
Superficial fascia
Posterior compartment

FIGURE 2.19 ■ Axial section of right arm. Inferior view.

## Skeletal Anatomy

Refer to an articulated skeleton or isolated humerus, radius, and ulna and identify the following skeletal features.

### *Distal Anterior Humerus*

ATLAS 2.3C

1. Refer to FIGURE 2.20.
2. On the distal end of the humerus, identify the **medial epicondyle** medially and the **lateral epicondyle** laterally.
3. Between the epicondyles, identify the depression of the **olecranon fossa** posteriorly and the **coronoid fossa** anteriorly.
4. Inferior to the epicondyles, identify the **trochlea** medially and the **capitulum** laterally.

### *Proximal Radius and Ulna*

ATLAS 2.3C, 2.3G

1. Refer to FIGURE 2.20.
2. On the proximal end of the radius, identify the **head of the radius**. The depression of the head of the radius articulates with the capitulum of the humerus and allows for flexion and extension at the elbow as well as rotational movement of the forearm.
3. Inferior to the head of the radius, identify the narrowed **neck of the radius**.
4. Distal to the neck of the radius, identify the **radial tuberosity**, the attachment site of the biceps brachii muscle.
5. Place the head of the radius in the **radial notch** of the ulna and observe that the **proximal radioulnar joint** allows for the rotational movements of pronation and supination of the forearm.
6. On the proximal end of the ulna, identify the **trochlear notch** located between the **olecranon process** and the **coronoid process**.
7. Articulate the ulna with the humerus and observe that flexion is limited by contact of the coronoid process in the coronoid fossa and that extension is limited by contact of the olecranon process in the olecranon fossa.
8. On a skeleton, examine the **elbow joint**. The elbow joint is the articulation between the trochlear notch of the ulna and the trochlea of the humerus and the head of the radius and the capitulum of the humerus. These two articulations account for the hinge action (flexion/extension) of the elbow joint.

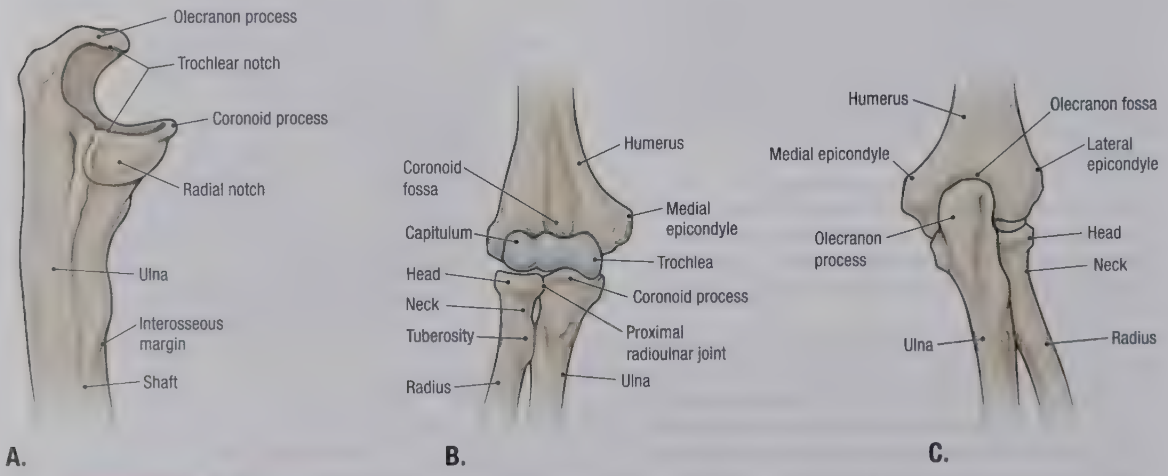

Olecranon process
Trochlear notch
Coronoid process
Radial notch
Ulna
Interosseous margin
Shaft
A.
Coronoid fossa
Capitulum
Head
Neck
Tuberosity
Radius
Humerus
Medial epicondyle
Trochlea
Coronoid process
Proximal radioulnar joint
Ulna
B.
Humerus
Medial epicondyle
Olecranon process
Ulna
Olecranon fossa
Lateral epicondyle
Head
Neck
Radius
C.

FIGURE 2.20 ■ **A.** Proximal ulna. Lateral view. **B.** Skeleton of the right elbow. Anterior view. **C.** Posterior view.

## Dissection Instructions

### Anterior Compartment of the Arm Muscles

ATLAS 2.36, 2.37; VIDEO 2.6.1

1. Refer to FIGURE 2.21.
2. With the cadaver in the supine position, use scissors to make a longitudinal incision in the anterior surface of the brachial fascia from the level of the pectoralis major tendon to the elbow.
3. Use blunt dissection to separate the brachial fascia from the underlying muscles. Work laterally and medially from the incision and note the presence of the **lateral intermuscular septum** and the **medial intermuscular septum**. Detach the brachial fascia from the intermuscular septa and place it in the tissue container.

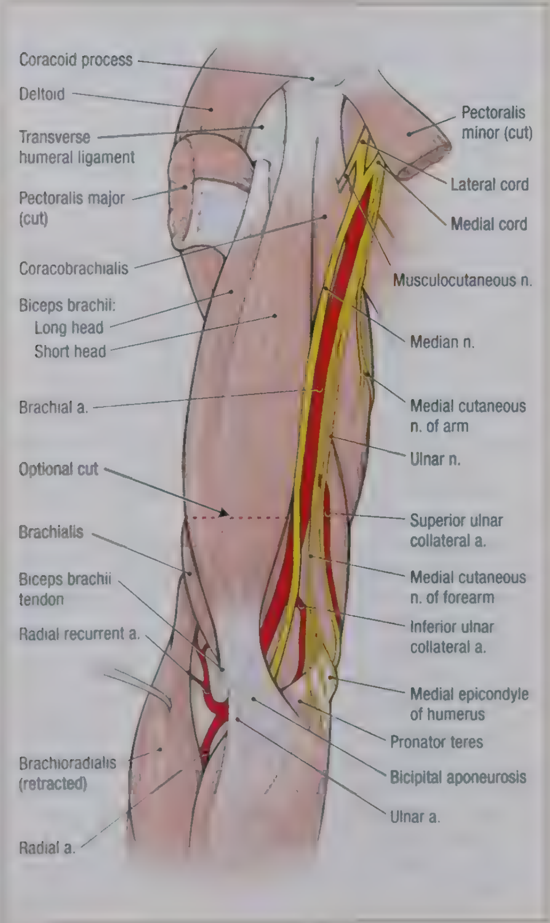

Coracoid process
Deltoid
Transverse humeral ligament
Pectoralis major (cut)
Coracobrachialis
Biceps brachii:
Long head
Short head
Brachial a.
Optional cut
Brachialis
Biceps brachii tendon
Radial recurrent a.
Brachioradialis (retracted)
Radial a.
Pectoralis minor (cut)
Lateral cord
Medial cord
Musculocutaneous n.
Median n.
Medial cutaneous n. of arm
Ulnar n.
Superior ulnar collateral a.
Medial cutaneous n. of forearm
Inferior ulnar collateral a.
Medial epicondyle of humerus
Pronator teres
Bicipital aponeurosis
Ulnar a.

FIGURE 2.21 ● Anterior compartment of right arm. Anterior view.

4. Use blunt dissection to separate the three muscles in the anterior compartment of the arm: **coracobrachialis**, **brachialis**, and **biceps brachii**.
5. Use blunt dissection to separate the two muscular bellies of the **biceps brachii muscle**.
6. Identify the more medially located **short head of the biceps brachii muscle** and clean the surface of its tendon superiorly where it attaches to the coracoid process of the scapula.
7. Identify the more laterally located **long head of the biceps brachii muscle**. Superiorly, the tendon of the long head of the biceps brachii muscle courses through the intertubercular sulcus of the humerus deep to the **transverse humeral ligament**, passes through the glenohumeral joint, and attaches to the **supraglenoid tubercle**. Do not follow the tendon of the long head to its attachment on the scapula or deep to the transverse humeral ligament.
8. Clean the surface of the biceps brachii muscle inferiorly and identify the **biceps brachii tendon** passing into the cubital fossa.
9. Review the attachments and actions of the biceps brachii muscle (see **TABLE 2.4**).
10. Identify the **bicipital aponeurosis**, an extension of the biceps tendon that broadens medially and attaches to the antebrachial fascia. *Note that the bicipital aponeurosis separates the superficially located median cubital vein from the underlying brachial artery and median nerve making this a safe place for venipuncture.*
11. Clean the surface of the coracobrachialis muscle paying attention to not disrupt the course of the musculocutaneous nerve. Confirm that the proximal attachment of the coracobrachialis muscle is the coracoid process of the scapula and that its distal attachment is on the medial side of the shaft of the humerus.
12. Review the attachments and actions of the coracobrachialis muscle (see **TABLE 2.4**).
13. Flex the elbow about 45° and gently pull the biceps brachii muscle medially or laterally to observe the more deeply located **brachialis muscle**.
14. On one side of the cadaver, transect the biceps brachii muscle about 5 cm proximal to the elbow (**Optional Cut**) taking care to not cut the musculocutaneous nerve.
15. Reflect the two portions of the biceps brachii muscle superiorly and inferiorly, respectively, to increase visibility of the underlying musculocutaneous nerve and brachialis muscle.
16. Follow the brachialis muscle distally into the cubital fossa and confirm that it attaches to the ulna.
17. Review the attachments and actions of the brachialis muscle (see **TABLE 2.4**).

## Neurovasculature of the Arm

ATLAS 2.39; VIDEO 2.6.2

1. Refer to FIGURE 2.21.
2. Identify the musculocutaneous nerve where it pierces the **coracobrachialis muscle** and recall that the musculocutaneous nerve innervates all three muscles of the anterior compartment of the arm.
3. Find the **musculocutaneous nerve** where it emerges from the coracobrachialis muscle and follow it through the plane of loose connective tissue between the biceps brachii and brachialis muscles. Observe that after the musculocutaneous nerve gives off its muscular branches, it continues distally as the **lateral cutaneous nerve of the forearm**.
4. Follow the lateral cutaneous nerve of the forearm to the cubital fossa where it emerges lateral to the biceps brachii tendon.
5. Review the relationship of the lateral cutaneous nerve of the forearm to the cephalic vein.
6. On the medial aspect of the arm, identify the **medial cutaneous nerve of the** forearm and follow it from the medial cord of the brachial plexus to the level of the cubital fossa.
7. Use blunt dissection to follow the **median nerve** distally from the axilla where it arises from the brachial plexus, to where it enters the cubital fossa medial to the biceps brachii tendon. *Note that the median nerve courses medial to the biceps brachii muscle within the **medial intermuscular septum**.*
8. Use blunt dissection to follow the **ulnar nerve** from the medial cord of the brachial plexus to a location posterior to the medial epicondyle of the humerus. *Note that the ulnar nerve courses in the medial intermuscular septum in the proximal arm and then comes to lie on the posterior surface of the medial intermuscular septum in the distal one-third of the arm.*
9. Follow the ulnar nerve posteriorly at the elbow and observe that it is in contact with the posterior surface of the medial epicondyle of the humerus. At this location, the nerve is commonly referred to as the "funny bone" and induces the tingling sensation commonly felt with impact to the elbow.
10. Refer to FIGURE 2.22.
11. Identify the **brachial artery**, the continuation of the axillary artery. The brachial artery begins at the inferior border of the teres major muscle and ends at the level of the elbow by branching into the **ulnar artery** and **radial artery**.
12. Remove the surrounding brachial fascia covering the brachial artery and verify that the brachial artery courses with the median nerve within the medial intermuscular septum. Observe that the median nerve is the only large structure to course along the anterior surface of the brachial artery.
13. Identify the **venae comitantes**, the paired veins coursing along the deep arteries of the arm. The two-to-one relationship of deep veins per deep artery will be seen throughout the limbs and is a good way to differentiate the appearance of vessels and nerves in the limbs.
14. Observe that the deep veins of the upper limb drain into the basilic vein near the axilla. *Note that the basilic vein changes its name to axillary vein after the deep veins of the arm have drained into it.*
15. The deep veins of the upper limb are named according to the corresponding artery that they follow. Remove the brachial veins and their tributaries to clear the dissection field while preserving the branches of the brachial artery.
16. The brachial artery has three named branches in the arm arising medially: **deep artery of the arm**, **superior ulnar collateral artery**, and **inferior ulnar collateral artery**. Several unnamed muscular branches also arise along the length of the brachial artery laterally.

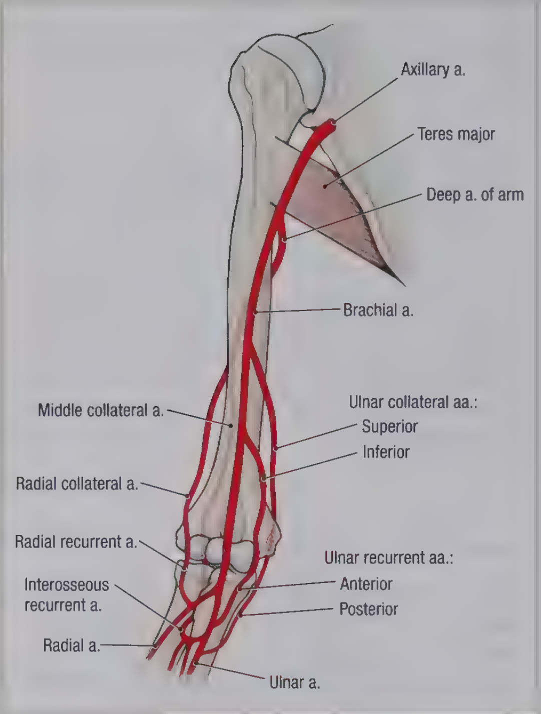


FIGURE 2.22 ● Brachial artery and collateral circulation of elbow. Anterior view.

CLINICAL CORRELATION

### Brachial Artery Variants and Damage

ATLAS 2.8A, 2.39, 2.59

When taking a blood pressure reading the brachial artery is purposely compressed where it lies close to the shaft of the humerus, medial to the biceps brachii muscle. Midshaft fractures of the humerus may sever the deep brachial artery of the arm as it wraps around the shaft, whereas more distal fractures may damage the brachial artery itself where it courses anteriorly. The deep artery can provide some collateral circulation to the rest of the arm particularly if a reduction of flow to the main artery occurs gradually.

Occasionally the brachial artery bifurcates in the arm rather than in the cubital fossa, a "high bifurcation", thus the ulnar artery may course superficial to the superficial layer of flexor muscles and be mistaken for a vein. Injection of drugs and medications into the artery, if mistaken for a vein, can have catastrophic consequences.

17. In the proximal arm, find the **deep artery of the arm** (**deep brachial artery** or **profunda brachii artery**) where it arises from the brachial artery. Recall that the deep artery of the arm courses around the posterior surface of the humerus where it accompanies the radial nerve in the radial groove, between the superior attachments of the medial and lateral heads of the triceps brachii muscle.
18. Identify and clean the **superior ulnar collateral artery** where it arises from the brachial artery about halfway down the arm. The superior ulnar collateral artery courses distally with the ulnar nerve and passes posterior to the medial epicondyle of the humerus. *Note that the superior ulnar collateral artery may arise from the profunda brachii artery.*
19. Identify and clean the **inferior ulnar collateral artery** where it arises from the brachial artery about 3 cm above the medial epicondyle of the humerus. Observe that the inferior ulnar collateral artery passes anterior to the medial epicondyle, deep to the **brachialis muscle**.

## Cubital Fossa

ATLAS 2.49; VIDEO 2.6.3

1. Refer to FIGURE 2.23.
2. Observe that the **cubital fossa** is bound laterally by the **brachioradialis muscle** and medially by the **pronator teres muscle**.

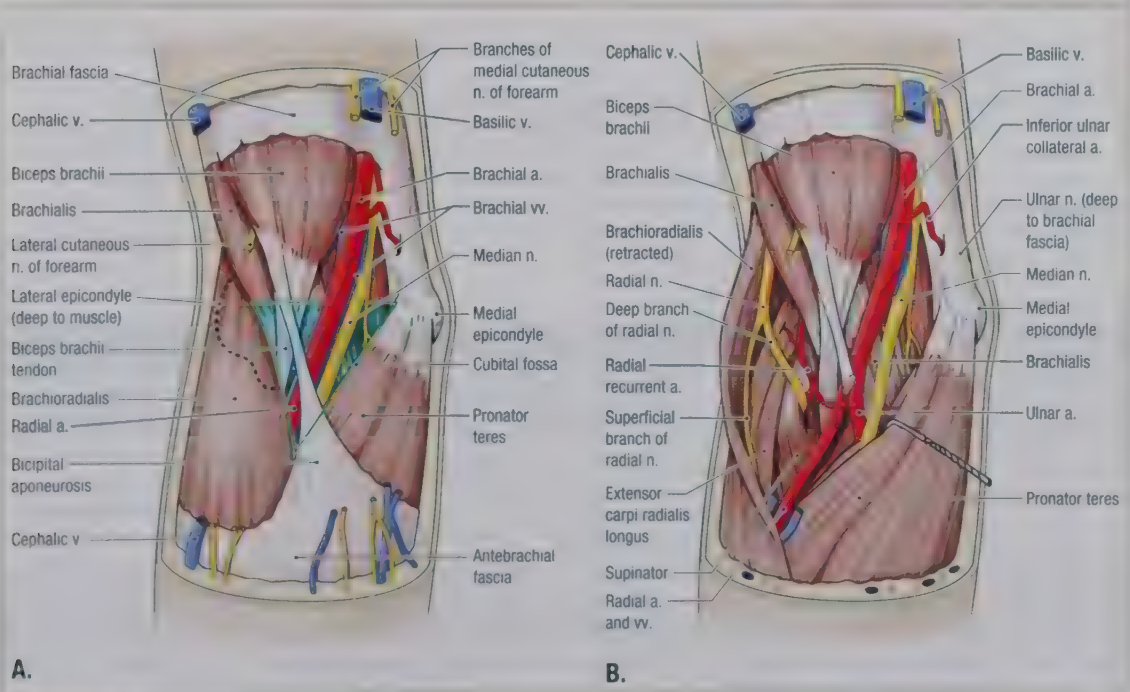

Brachial fascia
Cephalic v.
Biceps brachii
Brachialis
Lateral cutaneous n. of forearm
Lateral epicondyle (deep to muscle)
Biceps brachii tendon
Brachioradialis
Radial a.
Bicipital aponeurosis
Cephalic v
Branches of medial cutaneous n. of forearm
Basilic v.
Brachial a.
Brachial vv.
Median n.
Medial epicondyle
Cubital fossa
Pronator teres
Antebrachial fascia
A.
Cephalic v.
Biceps brachii
Brachialis
Brachioradialis (retracted)
Radial n.
Deep branch of radial n.
Radial recurrent a.
Superficial branch of radial n.
Extensor carpi radialis longus
Supinator
Radial a. and vv.
Basilic v.
Brachial a.
Inferior ulnar collateral a.
Ulnar n. (deep to brachial fascia)
Median n.
Medial epicondyle
Brachialis
Ulnar a.
Pronator teres
B.

FIGURE 2.23 A. Superficial dissection of the cubital fossa with representative superficial fascia, veins, and cutaneous nerves. B. Deep dissection of the cubital fossa. Anterior views.

3. Identify the **superior boundary of the cubital fossa**, an imaginary line connecting the medial and lateral epicondyles of the humerus.
4. Observe that the **superficial boundary (roof of the cubital fossa)** is the antebrachial fascia reinforced by the bicipital aponeurosis and that the **deep boundary (floor of the cubital fossa)** is the brachialis and supinator muscles.
5. Review the positions of the cephalic vein, basilic vein, and median cubital vein anterior to the cubital fossa. To gain access to deeper structures, it may be necessary to cut the perforating veins that connect the deep veins to the superficial veins and retract the vessels either medially or laterally as a group.
6. Identify and clean the **tendon of the biceps brachii muscle** in the cubital fossa.
7. Insert a probe deep to the **bicipital aponeurosis** near the biceps brachii tendon and gently slide it distally. Use scissors to cut the bicipital aponeurosis as far distally as possible to allow for lateral reflection of the portion still attached to the biceps tendon. Do not cut the brachial artery lying deep to the bicipital aponeurosis.
8. Follow the **median nerve** and the **brachial artery** from the arm into the cubital fossa removing any fat, veins, or lymphatics that may obstruct your view of these structures.
9. On the lateral aspect of the forearm, identify and clean the proximal end of the **brachioradialis muscle**.
10. Use blunt dissection to open the connective tissue plane between the brachioradialis muscle and the brachialis muscle in the arm and appreciate that the brachioradialis muscle originates in the posterior compartment of the arm.
11. Deep to the brachioradialis muscle, identify the radial nerve, previously identified in the posterior compartment of the arm.
12. Observe that the radial nerve passes anterior to the elbow joint near the lateral epicondyle and that it is accompanied by the **radial recurrent artery** at this location.
13. Observe the relative positions of three important structures in the cubital fossa from lateral to medial: biceps brachii tendon, brachial artery, and median nerve. The sequence of structures may be remembered by the simple mnemonic TAN (tendon, artery, nerve).
14. Deep to the contents of the cubital fossa, identify and clean the floor of the cubital fossa formed by the **brachialis muscle** and **supinator muscle**.

## Dissection Follow-up

1. Review the attachments, innervations, and actions of the muscles in the anterior and posterior compartments of the arm in **TABLE 2.4**.
2. Use the dissected specimen to review the origin, course, termination, and branches of the brachial artery.
3. Trace the paths of the musculocutaneous, median, ulnar, and radial nerves from the brachial plexus to the elbow, reviewing the key relationships of each.
4. Review the pattern of compartment innervation of the arm and the nerve territories of the brachial region.
5. Replace the muscles of the anterior compartment of the arm in their correct anatomical positions.
6. Refer back to FIGURE 2.16, a drawing of a cross section of the arm and note the position of the neurovascular structures within the fascia and intermuscular septa.

**TABLE 2.4 | Muscles of the Arm**

| ANTERIOR COMPARTMENT OF THE ARM | | | | |
|---|---|---|---|---|
| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
| Coracobrachialis | Coracoid process of the scapula | Medial side of shaft of humerus | Adducts and flexes the humerus | Musculocutaneous n. |
| Biceps brachii | Long head—supraglenoid tubercle of scapula; short head—coracoid process of the scapula | Radial tuberosity and antebrachial fascia | Supinates and flexes the forearm | |
| Brachialis | Anterior aspect of humerus | Tuberosity of the ulna | Flexes the forearm | |
| POSTERIOR COMPARTMENT OF THE ARM | | | | |
| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
| Triceps brachii | Long head—infraglenoid tubercle of the scapula; medial and lateral heads—posterior surface of the humerus | Olecranon process of the ulna | Extends the forearm | Radial n. |

Abbreviation: n., nerve.

# FLEXOR REGION OF THE FOREARM

## Dissection Overview

The antebrachial fascia (deep fascia of the forearm) is a sleeve of tough connective tissue investing the forearm. Antebrachial fascia is continuous at its proximal end with brachial fascia and distally with the palmar and dorsal fascia of the hand. Medial and lateral intermuscular septa project deeply from the antebrachial fascia to the radius and ulna. The intermuscular septa, the interosseous membrane, the radius, and the ulna combine to divide the forearm into an anterior (flexor) compartment and a posterior (extensor) compartment as shown in FIGURE 2.24.

The order of dissection will be as follows: The skeleton of the forearm will be studied. The structures in the superficial fascia of the forearm will be reviewed. The superficial fascia and the antebrachial fascia will be removed. At the level of the wrist, the relative positions of tendons, vessels, and nerves will be studied. The superficial and intermediate layers of flexor muscles will be studied and reflected on one side. Vessels and nerves that lie between the intermediate and deep layers of flexor muscles will be studied. The deep layer of flexor muscles will be dissected.

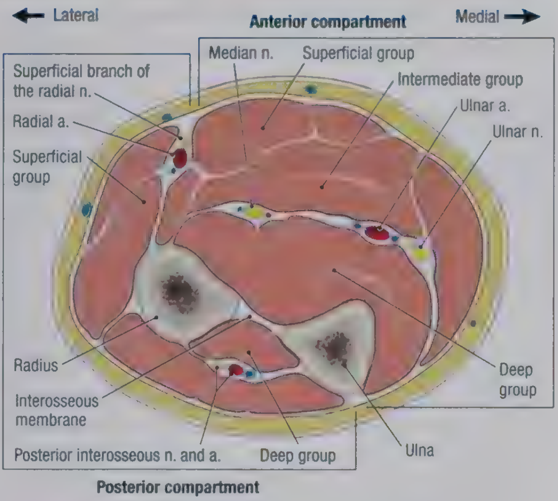

← Lateral
Anterior compartment
Medial →
Median n.
Superficial group
Intermediate group
Ulnar a.
Ulnar n.
Superficial branch of the radial n.
Radial a.
Superficial group
Radius
Interosseous membrane
Posterior interosseous n. and a.
Deep group
Ulna
Deep group
Posterior compartment

FIGURE 2.24 ■ Axial section through right forearm. Inferior view.

## Skeletal Anatomy

Refer to a skeleton or isolated humerus, radius, and ulna to identify the following skeletal features.

### *Distal Humerus*

ATLAS 2.53

1. Refer to FIGURE 2.25.
2. On the distal humerus, identify the **medial supraepicondylar ridge** superior to the medial epicondyle as well as the **lateral supraepicondylar ridge** superior to the lateral epicondyle.
3. Review the location of the capitulum, trochlea, coronoid fossa, and olecranon fossa.

### *Radius and Ulna*

ATLAS 2.53, 2.61A, 2.81A

1. Refer to FIGURE 2.25.
2. Review the location of the **head**, **neck**, and **radial tuberosity** of the radius.
3. Review the location of the **olecranon process**, the **trochlear notch**, and the **coronoid process of the ulna**.
4. On the anterior surface of the radius, identify the **anterior oblique line**.
5. Along the medial edge of the radius, identify the **interosseous border**, the thin region of the bone serving as the attachment site of the **interosseous membrane**.
6. At the distal end of the radius, identify the **ulnar notch** and the inferiorly oriented **styloid process**.
7. Articulate the radius and ulna and observe that the **head of the ulna** fits into the depression of the ulnar notch of the radius to create the **distal radioulnar joint**.

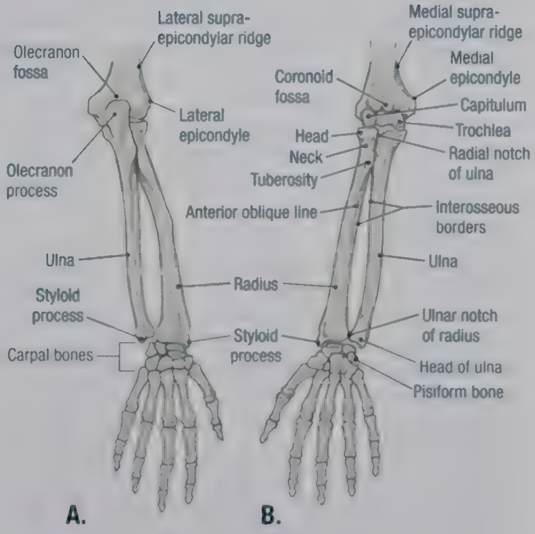

Olecranon fossa
Lateral supra-epicondylar ridge
Medial supra-epicondylar ridge
Medial epicondyle
Coronoid fossa
Capitulum
Lateral epicondyle
Trochlea
Head
Neck
Radial notch of ulna
Olecranon process
Tuberosity
Anterior oblique line
Interosseous borders
Ulna
Ulna
Radius
Styloid process
Ulnar notch of radius
Styloid process
Carpal bones
Head of ulna
Pisiform bone
A.
B.

FIGURE 2.25 ■ Skeleton of the right forearm. **A.** Posterior view. **B.** Anterior view.

8. Observe that the interosseous border of each bone is oriented at the corresponding ridge of the other bone.
9. Pronate and supinate the forearm of the skeleton and notice the rotational movements that occur at the proximal and distal radioulnar joints. In the position of supination (anatomical position), note that the radius and ulna are parallel, whereas in the position of pronation, the radius crosses anterior to the ulna.
10. On the palmar surface of the articulated hand, identify the **pisiform bone**.

## Dissection Instructions

### Superficial Layer of Flexor Muscles

ATLAS 2.63; VIDEO 2.7.1

1. Refer to FIGURE 2.26.
2. With the cadaver in the supine position, abduct the upper limb and actively supinate the forearm either using string to hold it in this position or have your dissection partner assist in orienting the upper limb throughout the dissection.
3. Remove the remnants of any remaining superficial fascia of the forearm taking care to preserve the cephalic and basilic veins. The other small veins in the region may be removed to clear the dissection field.
4. Use scissors to incise the anterior surface of the antebrachial fascia from the cubital fossa to the wrist.
5. Use blunt dissection to spread apart and separate the antebrachial fascia from the muscles that lie deep to it.
6. Detach the antebrachial fascia from its attachments to the radius and ulna along the intermuscular septa peripherally and place it in the tissue container.
7. Beginning on the medial aspect of the elbow, identify the four muscles in the **superficial layer of flexor muscles** of the forearm: the **pronator teres**, the **flexor carpi radialis**, the **palmaris longus**, and the **flexor carpi ulnaris**.
8. Use blunt dissection to separate the tendons of the **superficial layer of flexor muscles**. Observe that the bellies of the superficial muscles cannot be easily separated from each other proximally because they share a common flexor tendon.
9. Identify the **common flexor tendon** attached to the medial epicondyle of the humerus and note that it forms part of the proximal attachment of the muscles of the superficial layer.
10. Use blunt dissection to trace the belly of the **pronator teres muscle** toward the middle of the lateral surface of the radius and clean its proximal surface.
11. Clean the surface of the **flexor carpi radialis muscle** and follow its tendon toward its distal attachment.
12. In the middle of the forearm, identify the thin **palmaris longus tendon**. Follow and clean the palmaris longus distally toward its attachment to the palmar aponeurosis in the hand. *Note that this muscle and tendon are absent in some individuals.*
13. On the medial aspect of the forearm, identify and clean the **flexor carpi ulnaris muscle** and follow its tendon toward its distal attachments.
14. Review the attachments and actions of the **superficial layer of flexor muscles** (see **TABLE 2.5**).
15. On the anterior surface of the wrist, deep and lateral to the tendon of the **flexor carpi radialis muscle**, identify and clean the **radial artery**. *Note that the pulse of the radial artery can be felt at this location on the anterior distal surface of the radius in living individuals.*
16. Deep and lateral to the **palmaris longus tendon**, identify the **median nerve**. *Note that the median nerve is superficial at the wrist and can be easily injured.*
17. Deep and lateral to the tendon of the **flexor carpi ulnaris muscle**, identify and clean the **ulnar artery** and **ulnar nerve**.
18. In your own wrist, or that of a dissecting partner, palpate the flexor carpi radialis and ulnaris tendons and, if present, the tendon of the palmaris longus.
19. Feel the pulse of the radial artery between the abductor pollicis longus and flexor carpi radialis tendons and the ulnar artery lateral to the flexor carpi ulnaris and pisiform bone.

### Intermediate Layer of Flexor Muscles

ATLAS 2.64; VIDEO 2.7.2

***Dissection Note:*** Perform the following dissection sequence on only one side of the cadaver. Maintain the superficial relationships on the contralateral side. On the side where the deep dissection cuts are not made, simply use blunt dissection to retract the muscles and tendons to expose the underlying structures.

1. Refer to FIGURE 2.26.
2. Deep to the superficial layer of flexor muscles in the anterior compartment of the forearm, identify the distal portion of **flexor digitorum superficialis muscle**, the only muscle of the intermediate layer of forearm flexor muscles. *Note that to see the intermediate muscle fully, several muscles of the superficial layer must be transected and reflected on one limb.*
3. Use scissors to cut the tendon of the palmaris longus muscle proximal to the wrist (**Cut 1**) and reflect the tendon and muscle belly superiorly.
4. Cut the tendon of the flexor carpi radialis muscle proximal to the wrist (**Cut 2**) and reflect the tendon and muscle belly superiorly.
5. Identify the two heads of the pronator teres muscle; the **superficial (humeral) head** and the **deep (ulnar) head**. Observe that the median nerve passes between the two heads of the pronator teres.

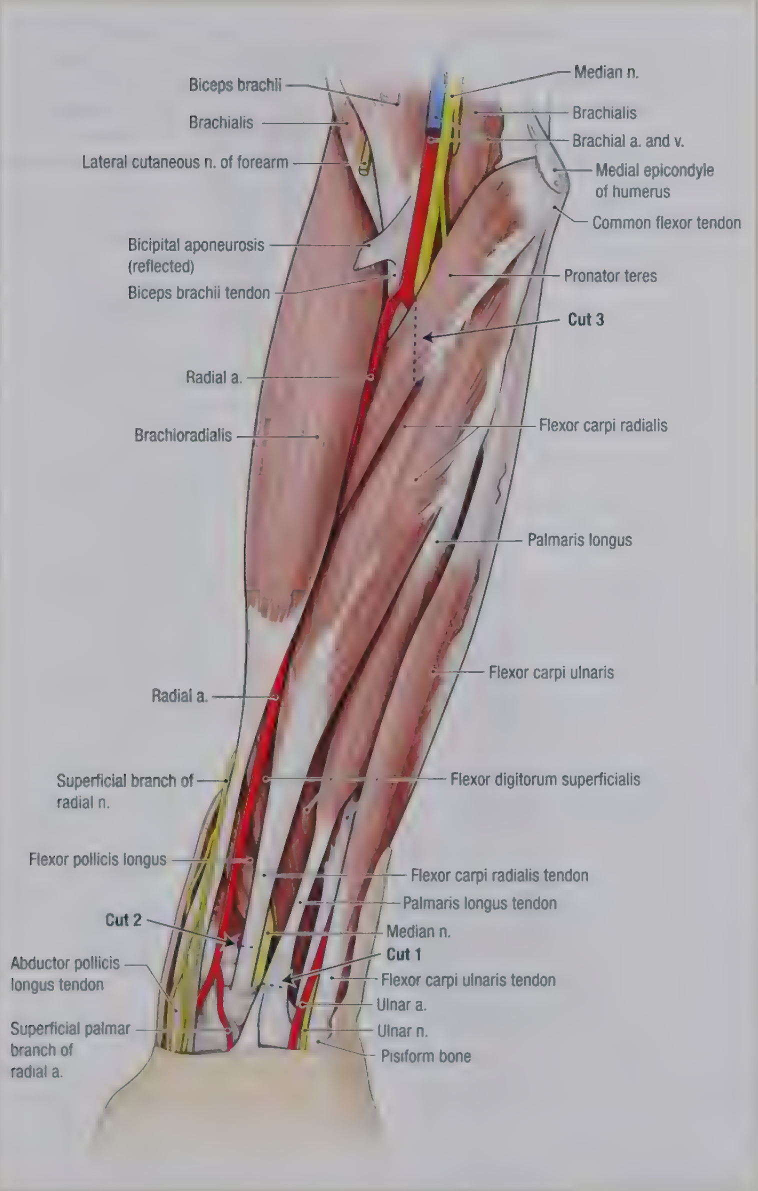

Biceps brachii
Brachialis
Lateral cutaneous n. of forearm
Bicipital aponeurosis (reflected)
Biceps brachii tendon
Radial a.
Brachioradialis
Radial a.
Superficial branch of radial n.
Flexor pollicis longus
Cut 2
Abductor pollicis longus tendon
Superficial palmar branch of radial a.
Median n.
Brachialis
Brachial a. and v.
Medial epicondyle of humerus
Common flexor tendon
Pronator teres
Cut 3
Flexor carpi radialis
Palmaris longus
Flexor carpi ulnaris
Flexor digitorum superficialis
Flexor carpi radialis tendon
Palmaris longus tendon
Median n.
Cut 1
Flexor carpi ulnaris tendon
Ulnar a.
Ulnar n.
Pisiform bone

FIGURE 2.26 ■ Superficial layer of flexor muscles in the right forearm. Anterior view.

6. Insert a probe between the two heads of the pronator teres muscle along the anterior surface of the median nerve.
7. Transect the humeral head of the pronator teres muscle anterior to the probe (**Cut 3**) and reflect it medially.
8. Refer to FIGURE 2.27.
9. Identify the proximal portion of **flexor digitorum superficialis muscle** and observe that proximally it has three attachments that create a tendinous arch spanning over the path of the ulnar artery and median nerve.
10. Observe that distally, the flexor digitorum superficialis muscle gives rise to four individual tendons that attach to the middle phalanges of digits 2 to 5.

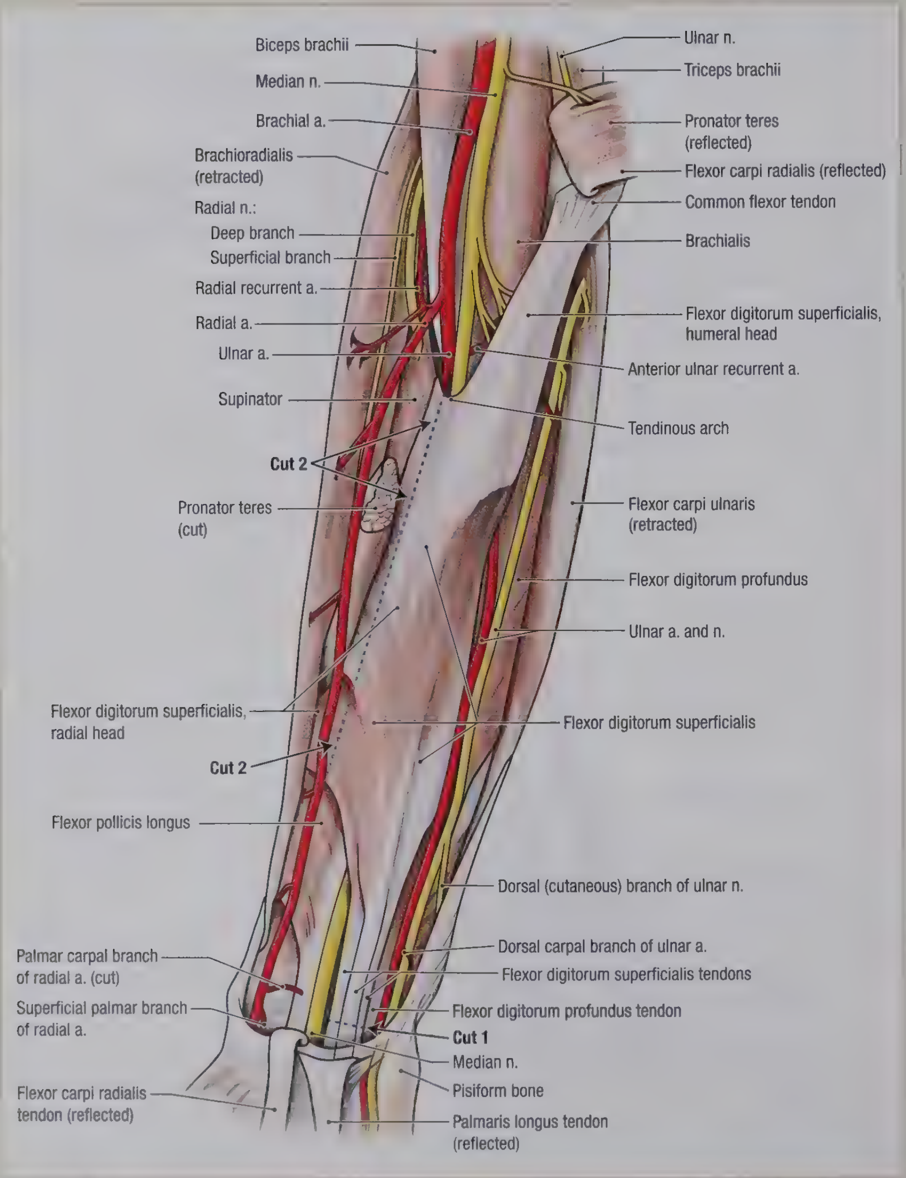

Biceps brachii
Median n.
Brachial a.
Brachioradialis (retracted)
Radial n.:
Deep branch
Superficial branch
Radial recurrent a.
Radial a.
Ulnar a.
Supinator
Cut 2
Pronator teres (cut)
Flexor digitorum superficialis, radial head
Cut 2
Flexor pollicis longus
Palmar carpal branch of radial a. (cut)
Superficial palmar branch of radial a.
Flexor carpi radialis tendon (reflected)
Ulnar n.
Triceps brachii
Pronator teres (reflected)
Flexor carpi radialis (reflected)
Common flexor tendon
Brachialis
Flexor digitorum superficialis, humeral head
Anterior ulnar recurrent a.
Tendinous arch
Flexor carpi ulnaris (retracted)
Flexor digitorum profundus
Ulnar a. and n.
Flexor digitorum superficialis
Dorsal (cutaneous) branch of ulnar n.
Dorsal carpal branch of ulnar a.
Flexor digitorum superficialis tendons
Flexor digitorum profundus tendon
Cut 1
Median n.
Pisiform bone
Palmaris longus tendon (reflected)

FIGURE 2.27 ■ Intermediate layer of flexor (anterior compartment) muscles in right forearm. Anterior view.

11. Proximal to the wrist, observe that the four tendons of the flexor digitorum superficialis muscle lie between the median nerve and the ulnar artery and nerve.
12. Review the attachments and actions of the **flexor digitorum superficialis muscle** (see **TABLE 2.5**)

## Vessels and Nerves of the Anterior Forearm

ATLAS 2.64B, 2.65B; VIDEO 2.7.3

1. Refer to FIGURE 2.27.
2. On the lateral side of the proximal forearm, identify the brachioradialis muscle.

3. At the point where the pronator teres muscle passes deep to the brachioradialis muscle, use blunt dissection to open the connective tissue plane deep to the brachioradialis muscle and identify the **superficial branch of the radial nerve**.
4. Follow the superficial branch of the radial nerve to the distal one-third of the forearm and confirm that it emerges on the posterior side of the brachioradialis tendon and distributes to the dorsum of the hand.
5. In the cubital fossa, use blunt dissection to follow the **brachial artery** distally until it bifurcates into the **radial artery** and the **ulnar artery**.
6. Clean the radial artery and follow it distally as far as the level of the wrist. The radial veins and their tributaries may be removed to clear the dissection field. *Note that the radial artery gives rise to several unnamed muscular branches in the forearm.*
7. Find the **radial recurrent artery** arising from the radial artery near its origin from the brachial artery.
8. Observe that the radial recurrent artery courses superiorly in the connective tissue plane between the brachioradialis muscle and the brachialis muscle to anastomose with the radial collateral branch of the deep artery of the arm. Recall that the radial recurrent artery is part of the anastomotic network around the elbow.
9. Identify the **median nerve** in the cubital fossa and observe that it is positioned medial to the brachial artery and that it passes deep to the flexor digitorum superficialis muscle. The median nerve innervates all but one and a half muscles of the flexor compartment of the forearm.
10. To expose the distal part of the median nerve, the flexor digitorum superficialis muscle must be cut and retracted. On one upper limb only, use scissors to cut the four tendons of the flexor digitorum superficialis muscle proximal to the wrist (**Cut 1**). On the contralateral limb, use blunt dissection to separate the layers and tendons of the muscles.
11. Detach the flexor digitorum superficialis muscle from its attachment on the anterior oblique line of the radius (**Cut 2**), paying attention to not cut the radial artery.
12. Retract the flexor digitorum superficialis muscle medially, leaving it attached to the ulna and medial epicondyle of the humerus.
13. Refer to FIGURE 2.28.
14. Use a probe to free the median nerve from the loose connective tissue that lies between the intermediate and deep layers of forearm flexor muscles.
15. Observe that the median nerve gives small muscular branches to the palmaris longus, flexor carpi radialis, flexor digitorum superficialis, and pronator teres muscles.
16. Identify the **anterior interosseous nerve**, which arises from the median nerve and innervates the deep layer of forearm flexor muscles.
17. Find the **ulnar artery** in the cubital fossa and observe that it passes posterior to the deep head of the pronator teres muscle.
18. Insert a probe along the anterior surface of the ulnar artery, posterior to the deep head of the pronator teres muscle.
19. Using the inserted probe as a guide, cut the deep head of the pronator teres muscle and reflect the now fully transected muscle to broaden the dissection field.
20. Clean the ulnar artery by removing the ulnar veins and their tributaries and follow it from the cubital fossa to the wrist.
21. Observe that the ulnar artery passes posterior to the median nerve in the cubital fossa between the flexor digitorum superficialis and the flexor digitorum profundus muscles and that it is joined by the **ulnar nerve** about one-third of the way down the forearm.
22. Observe that the ulnar artery and nerve lie deep to the flexor carpi ulnaris muscle in the distal forearm and pass into the hand on the lateral side of the pisiform bone at the wrist.

## CLINICAL CORRELATION

### Nerve Injuries (Radial, Median, and Ulnar Nerve Neuropathies)

ATLAS 2.41

The radial nerve is vulnerable to injury within the radial groove at the lateral aspect of the elbow where it crosses anterior to the lateral epicondyle or as it pierces the supinator muscle. Distal trauma or compression of the radial nerve affects the extensor compartment of forearm, resulting in a weakened ability to extend the wrist or digits (wrist drop), whereas proximal injury may also affect the triceps brachii resulting in weakness of elbow extension, and sensory loss to the region superficial to the snuffbox.

The median nerve is vulnerable to trauma in the cubital fossa, where it pierces the two heads of the pronator teres, in the carpal tunnel, or within the lateral palm. Depending on the location of the injury, the patient may present with weakness or loss of wrist flexion, impaired flexion of digits 1 and 2 (hand of benediction), lack of opposition of the thenar muscles (thenar wasting), and sensory deficits in the palm and first 3½ digits.

The ulnar nerve is vulnerable to trauma where it courses posterior to the medial epicondyle, in the cubital fossa, at the wrist within Guyon's canal, or in the hand. Depending on the site of trauma, the patient may present with loss or weakness of wrist adduction, impaired adduction and abduction of the digits (claw hand), weakness of flexion of digits 4 and 5, and sensory deficits in the medial palm and last 1½ digits.

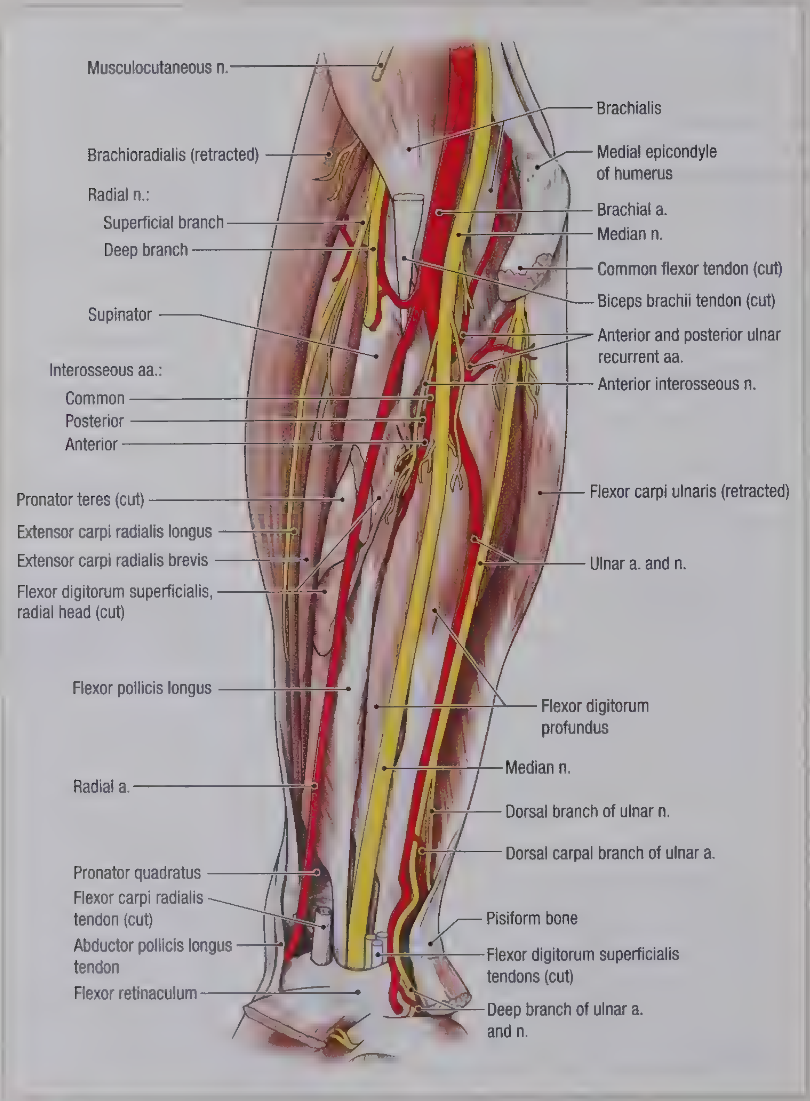

Musculocutaneous n.
Brachioradialis (retracted)
Radial n.:
Superficial branch
Deep branch
Supinator
Interosseous aa.:
Common
Posterior
Anterior
Pronator teres (cut)
Extensor carpi radialis longus
Extensor carpi radialis brevis
Flexor digitorum superficialis, radial head (cut)
Flexor pollicis longus
Radial a.
Pronator quadratus
Flexor carpi radialis tendon (cut)
Abductor pollicis longus tendon
Flexor retinaculum
Brachialis
Medial epicondyle of humerus
Brachial a.
Median n.
Common flexor tendon (cut)
Biceps brachii tendon (cut)
Anterior and posterior ulnar recurrent aa.
Anterior interosseous n.
Flexor carpi ulnaris (retracted)
Ulnar a. and n.
Flexor digitorum profundus
Median n.
Dorsal branch of ulnar n.
Dorsal carpal branch of ulnar a.
Pisiform bone
Flexor digitorum superficialis tendons (cut)
Deep branch of ulnar a. and n.

FIGURE 2.28 ■ Deep layer of flexor (anterior compartment) muscles in right forearm. Anterior view.

23. Identify and clean the **common interosseous artery**, a branch of the ulnar artery that arises about 3 cm distal to the origin of the ulnar artery.
24. Observe that the common interosseous artery courses posterolaterally toward the interosseous membrane before dividing into the **anterior interosseous artery** and the **posterior interosseous artery**. *Note that the common interosseous artery is usually quite short and may be absent, so the anterior and posterior interosseous arteries arise directly from the ulnar artery.*
25. Identify the **anterior interosseous artery** and follow it distally on the anterior surface of the interosseous membrane between the muscles of the deep layer of forearm flexor muscles.
26. At the proximal end of the interosseous membrane, identify the **posterior interosseous artery** and observe that it passes posteriorly to enter the posterior compartment of the forearm to supply the extensor group of forearm muscles. Do not attempt to follow it into the posterior compartment at this time.

27. Two other named vessels arise from the ulnar artery in the proximal forearm: the **anterior ulnar recurrent artery** and the **posterior ulnar recurrent artery**. The anterior and posterior ulnar recurrent arteries anastomose with the inferior and superior ulnar collateral branches of the brachial artery, respectively. *Note that several muscular branches arise from the ulnar artery in the forearm.*
28. Identify the ulnar nerve in the distal forearm and follow it proximally.
29. Near the elbow, observe that the ulnar nerve courses posterior to the medial epicondyle of the humerus and penetrates the flexor carpi ulnaris muscle. The ulnar nerve innervates the flexor carpi ulnaris muscle and the medial half of the flexor digitorum profundus muscle.

## Deep Layer of Flexor Muscles

ATLAS 2.65; VIDEO 2.7.4

1. Refer to FIGURE 2.28.
2. Three muscles comprise the **deep layer of forearm flexor muscles: flexor digitorum profundus, flexor pollicis longus**, and **pronator quadratus**.
3. Identify and clean the surface of the **flexor digitorum profundus muscle**. *Note that the flexor digitorum profundus muscle has two motor nerves: The lateral half of the muscle is innervated by the anterior interosseous branch of the median nerve, and the medial half is innervated by the ulnar nerve.*
4. Observe that distally the flexor digitorum superficialis muscle gives rise to four individual tendons that attach to the distal phalanges of digits 2 to 5.
5. Review the attachments and actions of the **flexor digitorum profundus muscle** (see **TABLE 2.5**).
6. On the radial side of the forearm, identify and clean the **flexor pollicis longus muscle**, which is readily identifiable due to its "feather-like" appearance with all the muscle fibers attaching to one side of the tendon.
7. Review the attachments and actions of the **flexor pollicis longus muscle** (see **TABLE 2.5**).
8. Refer to FIGURE 2.29.
9. Retract the tendons of the flexor digitorum profundus and flexor pollicis longus muscles medially and laterally, respectively, and identify the **pronator quadratus muscle**.
10. Observe that the fibers of the pronator quadratus muscle run transversely from the ulna to the radius.
11. In the distal forearm, observe that the **anterior interosseous artery and nerve** pass between the pronator quadratus muscle and the interosseous membrane.

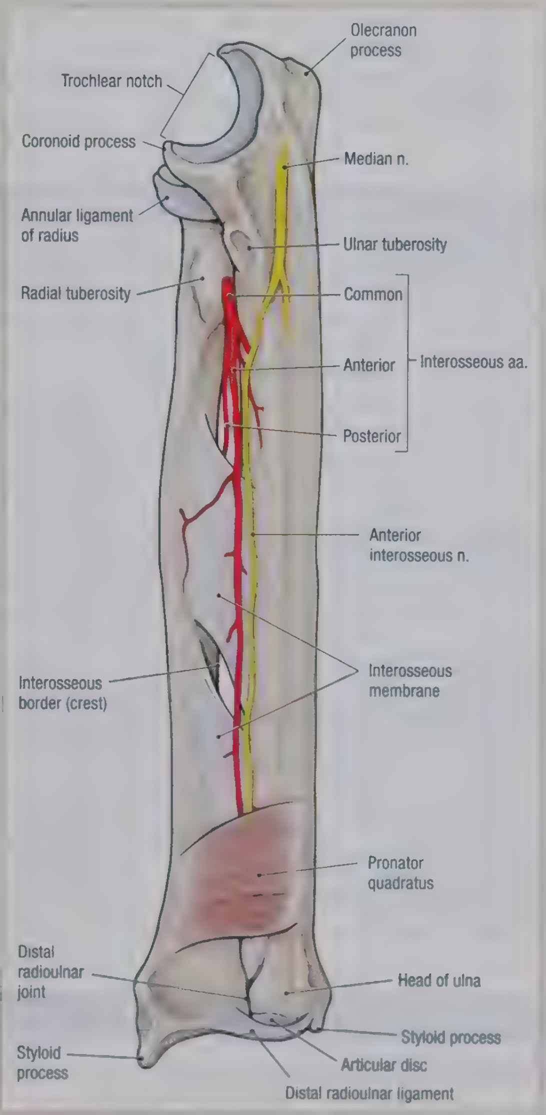

Olecranon process
Trochlear notch
Coronoid process
Median n.
Annular ligament of radius
Ulnar tuberosity
Radial tuberosity
Common
Anterior
Interosseous aa.
Posterior
Anterior interosseous n.
Interosseous border (crest)
Interosseous membrane
Pronator quadratus
Distal radioulnar joint
Head of ulna
Styloid process
Styloid process
Articular disc
Distal radioulnar ligament

FIGURE 2.29 ● Interosseous neurovasculature of right forearm. Anterior view.

## Dissection Follow-up

1. Review the attachments and actions of the superficial, intermediate, and deep groups of muscles in the anterior compartment of the forearm in **TABLE 2.5**.
2. Follow the brachial artery from its origin in the proximal arm to its bifurcation in the cubital fossa.
3. Review the branches of the radial and ulnar arteries and trace the course of these two arteries from the elbow to the wrist.
4. Review the course of the median nerve and its branches from the brachial plexus to the wrist and its pattern of motor distribution to the anterior forearm.
5. Review the course of the ulnar nerve and its branches from the brachial plexus to the wrist and its pattern of motor distribution to the anterior forearm.
6. Replace the flexor muscles in their correct anatomical positions, taking care to align the cut tendons correctly.

**TABLE 2.5 Anterior Compartment of the Forearm**

SUPERFICIAL GROUP OF MUSCLES

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Pronator teres | Medial epicondyle, supraepicondylar ridge, medial side of coronoid process | Lateral midshaft of radius | Pronates and flexes the forearm | Median n. |
| Flexor carpi radialis | Medial epicondyle of humerus | Base of metacarpals 2–3 | Flexes and abducts the wrist | |
| Palmaris longus | | Palmar aponeurosis | Flexes the wrist | |
| Flexor carpi ulnaris | | Pisiform bone and base of metacarpal 5 | Flexes and adducts the wrist | Ulnar n. |

INTERMEDIATE GROUP OF MUSCLES

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Flexor digitorum superficialis | Medial epicondyle of humerus and oblique line of radius | Middle phalanges of digits 2–5 | Flexes PIP of digits 2–5 | Median n. |

DEEP GROUP OF MUSCLES

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Flexor digitorum profundus | Anterior and medial surface of ulna and interosseous membrane | Distal phalanges of digits 2–5 | Flexes DIP of digits 2–5 | Lateral half—anterior interosseous n.; medial half—ulnar n. |
| Flexor pollicis longus | Anterior surface of radius and interosseous membrane | Base of distal phalanx of thumb | Flexes IP of thumb | Anterior interosseous branch of median n. |
| Pronator quadratus | Distal radius | Distal ulna | Pronates the forearm | |

Abbreviations: DIP, distal interphalangeal joint; IP, interphalangeal joint; n., nerve; PIP, proximal interphalangeal joint.

# PALM OF THE HAND

## Dissection Overview

There are two superficial groups of intrinsic hand muscles: the thenar group of muscles and the hypothenar group of muscles. The other intrinsic groups of muscles lie deep in the hand and include the interosseous muscles, which abduct and adduct digits 2 to 5; the adductor pollicis muscle, which adducts digit 1; and the lumbricals, which assist in flexion of the metacarpophalangeal (MCP) joint and extension of the proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints. On the palmar aspect of the hand, the extrinsic muscles reach the hand via the carpal tunnel and are responsible for flexing the digits and assisting wrist flexion.

In the palm, two arterial arches course between the muscle layers. The superficial palmar arch is mainly derived from the ulnar artery, whereas the deep palmar arch arises from the radial artery. The nerve supply of the palmar aspect of the hand is from the median and ulnar nerves.

The order of dissection will be as follows: The skeleton of the hand will be reviewed. The palmar aponeurosis will be studied and removed. The superficial palmar arch will be dissected, followed by the tendons of the muscles of the anterior compartment of the forearm. The transverse carpal ligament will be cut, and the flexor tendons will be released from the palm. The flexor tendons will be followed into the palm, and the lumbricals will be studied. The muscles of the thenar and hypothenar groups will be dissected. The deep palmar arch will be dissected along with the deep branch of the ulnar nerve. The adductor pollicis and interosseous muscles will be studied.

## Skeletal Anatomy

Refer to a skeleton or an articulated hand and identify the following skeletal features.

### *Skeleton of the Hand*

ATLAS 2.61, 2.68B

1. Refer to FIGURE 2.30.
2. Identify the **eight carpal bones** collectively in the proximal hand and observe that they are positioned in essentially two rows of four.
3. In the proximal row of carpal bones from lateral to medial, identify the **scaphoid**, **lunate**, **triquetrum**, and **pisiform**.
4. In the distal row of carpal bones from lateral to medial, identify the **trapezium**, **trapezoid**, **capitate**, and **hamate**.
5. Identify the five **metacarpals**, numbered from 1 to 5 from lateral to medial with the thumb counting as the 1st digit and the "pinky" or little finger counting as the 5th.
6. Observe that digit 1 (the thumb) has two phalanges: a proximal and a distal.
7. Observe that digits 2 to 5 (the fingers) have three phalanges: a **proximal**, a **middle**, and a **distal**.
8. On the medial side of the carpal bones, identify the pisiform and the **hook of the** hamate and on the lateral side of the carpal bones, identify the **tubercle of the scaphoid** and the **tubercle of the trapezium**. *Note that a portion of the **flexor retinaculum**, the **transverse carpal ligament**, bridges the carpal bones between these landmarks.*
9. The space between the carpal bones and the overlying transverse carpal ligament is the **carpal tunnel**, which allows passage of nine flexor tendons and the median nerve into the hand.

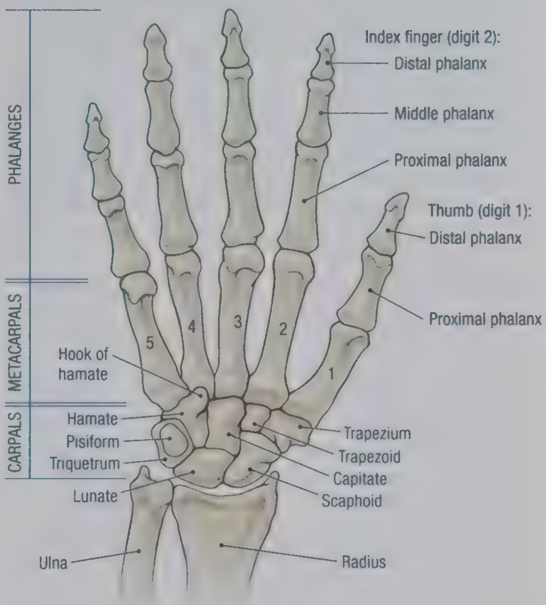


FIGURE 2.30 ● Skeleton of the right wrist and hand. Anterior (palmar) view.

# Dissection Instructions

## Skin Incisions of the Palm

VIDEO 2.8.1

***Dissection Note:*** In many cadavers, the hand may be stuck in a clenched position after the embalming process, making it very difficult to dissect the palm. If this is the case, flex the wrist and gently force open the clenched digits and have a dissection partner hold it open or use string to maintain the position.

1. Refer to FIGURE 2.31.
2. With the cadaver in the supine position, make a longitudinal incision from the midline of the wrist (E) along the palm to a point near the base of the third digit (M), the midline of the hand.

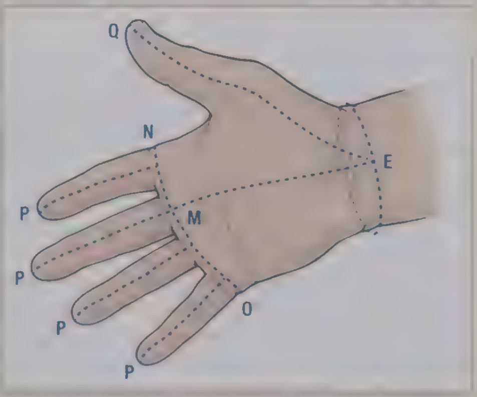


FIGURE 2.31 ● Skin incisions of the hand. Anterior (palmar) view.

3. Make a transverse incision proximal to the level of the webs of the fingers beginning laterally at the base of the 2nd digit (N) to the base of the 5th digit (O).
4. Make a longitudinal incision on the anterior surface of digits 2 to 5 from the transverse palm incision (N to O) to the tip of each digit (P). *Note that the subcutaneous tissue on the palmar surface of the digits is very thin, especially at the skin creases; thus, it is recommended to proceed with caution while making incisions in this region.*
5. Make a longitudinal incision from the midline of the wrist (E) along the palmar surface of the thumb to the tip of 1st digit (Q).
6. Beginning in the midline of the palm and working toward the periphery, remove the thick skin from the palmar surface of the hand staying superficial to the palmar aponeurosis.
7. Remove the skin by cutting along the medial and lateral aspects of the hand and carefully freeing it from the underlying aponeurosis. Place it in the tissue container.
8. Reflect the skin of the digits away from the midlines paying attention to not damage the underlying fibrous digital sheaths and work peripherally taking care to avoid damaging the digital nerves and vessels coursing along the length of each digit.
9. Remove the palmar skin of the digits by cutting along the periphery of each digit.
10. Turn the hand over and remove the skin on the dorsum of the hand. *Note that the skin on the dorsum of the hand is much thinner and more loosely attached than the skin on the palm. Exercise caution while removing the thin skin to not damage the underlying superficial veins on the dorsum of the hand.*
11. Remove the skin on the dorsum of the hand to a point just distal to the carpometacarpal joint leaving the skin on the posterior surface of the digits intact at this point in the dissection.

## Superficial Palm

ATLAS 2.69B, 2.74A; VIDEO 2.8.2

1. Refer to FIGURE 2.32.
2. On the palmar surface of the hand, identify the **palmar fascia**, a continuation of the antebrachial fascia in the forearm.
3. Observe that the palmar fascia thickens centrally as the **palmar aponeurosis**, the distal attachment of the palmaris longus.
4. Carefully use scraping motions with a scalpel blade to clean the fat from the palmar aponeurosis. Observe that the palmar aponeurosis has four bands of **longitudinal fibers**, one band to each of the digits 2 to 5, which end by attaching to the fibrous digital sheath near the base of the proximal phalanx of each digit.

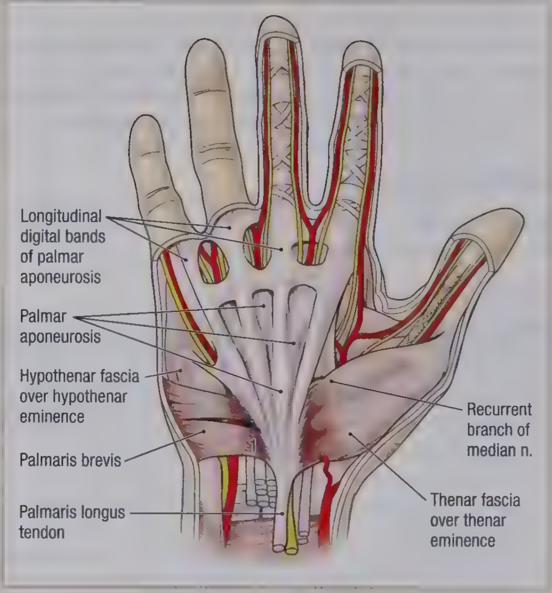

Longitudinal digital bands of palmar aponeurosis
Palmar aponeurosis
Hypothenar fascia over hypothenar eminence
Palmaris brevis
Palmaris longus tendon
Recurrent branch of median n.
Thenar fascia over thenar eminence

FIGURE 2.32 ● Superficial right palm. Anterior (palmar) view.

5. Identify the palmar fascia covering the **thenar muscles** lateral to the palmar aponeurosis and observe that it is a much thinner fascia than the palmar aponeurosis.
6. Identify the palmar fascia covering the hypothenar muscles medial to the palmar aponeurosis and the **palmaris brevis muscle**. The palmaris brevis muscle is a thin, fragile muscle responsible for contracting the skin at the base of the medial palm and may not be readily visible in many cadavers.
7. Detach the palmaris brevis muscle from the palmar aponeurosis (**Cut 1**) and reflect it medially.
8. Find the tendon of the **palmaris longus muscle** in the forearm and follow it distally into the palm to where it is attached to the palmar aponeurosis.
9. Near its distal attachments, use a probe to elevate the palmar aponeurosis away from the underlying structures in the palm. *Note that although the palmaris longus muscle may be absent, the palmar aponeurosis is always present.*
10. In the forearm where the palmaris longus tendon was cut, use the distal palmaris longus tendon to apply traction to the palmar aponeurosis during its removal. Use a scalpel and skinning motions to detach the palmar aponeurosis from the underlying structures.
11. While reflecting the palmar aponeurosis, do not cut too deeply because the superficial palmar arch is in contact with its deep surface. Similarly, be careful to preserve the **recurrent branch of the median nerve** entering the thenar eminence along its distal margin.
12. Near the proximal end of digits 2 and 3, remove the band of longitudinal fibers of the palmar aponeurosis.

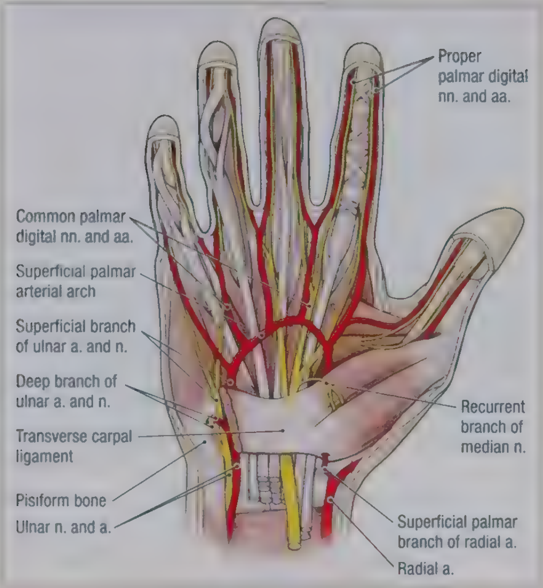

Proper palmar digital nn. and aa.
Common palmar digital nn. and aa.
Superficial palmar arterial arch
Superficial branch of ulnar a. and n.
Deep branch of ulnar a. and n.
Transverse carpal ligament
Pisiform bone
Ulnar n. and a.
Recurrent branch of median n.
Superficial palmar branch of radial a.
Radial a.

FIGURE 2.33 ● Superficial right palm with removed palmar aponeurosis. Anterior (palmar) view.

13. On the upper limb with the superficial dissection, remove the palmar aponeurosis beginning distally. Using the same techniques with the scalpel, carefully detach the palmar aponeurosis from the underlying structures and reflect it superiorly, leaving it attached to the tendon of the palmaris longus.
14. Refer to FIGURE 2.33.
15. Identify the **ulnar artery** in the forearm and, using blunt dissection, follow it into the palm lateral to the pisiform bone with the ulnar nerve, to where it divides into a **superficial branch** and a **deep branch**.
16. Observe that the superficial branch of the ulnar artery crosses the palm to form the **superficial palmar arterial arch**. The superficial palmar arterial arch is completed by a smaller contribution from the **superficial palmar branch of the radial artery**.
17. Use blunt dissection to clean the superficial palmar arterial arch as well as the vessels arising from it, the **common palmar digital arteries**.
18. Trace one or two common palmar digital arteries distally and note that they divide into two **proper palmar digital arteries** supplying the adjacent sides of two digits.
19. Find the **ulnar nerve** lateral to the pisiform bone and use a probe to dissect the **superficial branch of the ulnar nerve**, which supplies cutaneous innervation to digit 5 and the medial side of digit 4.
20. Follow the **deep branch of the ulnar nerve**, a short distance until it disappears between the hypothenar muscles.

## Carpal Tunnel

ATLAS 2.74B, 2.77; VIDEO 2.8.3

1. Refer to FIGURE 2.34.
2. Identify the **transverse carpal ligament**, the roof of the carpal tunnel, between the thenar and hypothenar eminences.
3. Insert a probe deep to the transverse carpal ligament from proximal to distal.
4. Use a scalpel to cut through the transverse carpal ligament superficial to the probe and open the carpal tunnel (**Cut 1**).
5. Refer to FIGURE 2.35.
6. Examine the **contents of the carpal tunnel: median nerve, four tendons of the flexor digitorum superficialis muscle, four tendons of the flexor digitorum profundus muscle,** and the **tendon of the flexor pollicis longus muscle.**
7. Find the median nerve at the level of the wrist and follow it through the carpal tunnel.
8. Identify and clean the median nerve in the hand as well as its various branches. The median nerve innervates five muscles in the hand: **lumbrical muscles 1 and 2**, via common palmar digital nerves, as well as the three thenar muscles via the **recurrent branch of the median nerve**.
9. Follow the **common palmar digital branches** of the median nerve toward the lateral 3½ digits. Note that the common palmar digital nerves typically divide to give rise to two **proper palmar digital nerves**, which accompany the proper palmar digital arteries. Use an illustration to study the cutaneous distribution of the median nerve in the hand.

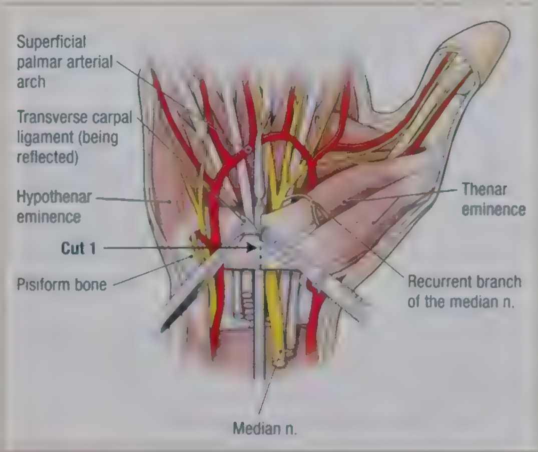

Superficial palmar arterial arch
Transverse carpal ligament (being reflected)
Hypothenar eminence
Cut 1
Pisiform bone
Thenar eminence
Recurrent branch of the median n.
Median n.

FIGURE 2.34 ● Opening right carpal tunnel. Anterior (palmar) view.

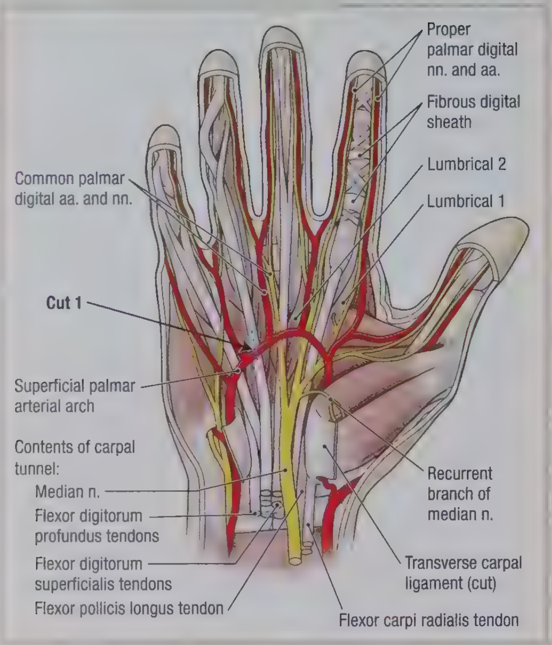

Proper palmar digital nn. and aa.
Fibrous digital sheath
Lumbrical 2
Lumbrical 1
Common palmar digital aa. and nn.
Cut 1
Superficial palmar arterial arch
Contents of carpal tunnel:
Median n.
Flexor digitorum profundus tendons
Flexor digitorum superficialis tendons
Flexor pollicis longus tendon
Recurrent branch of median n.
Transverse carpal ligament (cut)
Flexor carpi radialis tendon

FIGURE 2.35 ■ Contents of right carpal tunnel in intermediate palm. Anterior (palmar) view.

10. Cut the superficial palmar arch in the midline of the palm (**Cut 1**) and retract the common digital branches of the median and ulnar nerves laterally and medially, respectively.
11. Identify and clean the flexor tendons that pass through the carpal tunnel. Observe that the flexor tendons pass through the palm of the hand deep to the superficial palmar arch and digital nerves and then enter the fibrous digital sheaths on the anterior surfaces of the digits.

***Dissection Note:*** Perform the following dissection steps only on the upper limb with the deep dissection already performed in the forearm.

12. Refer to FIGURE 2.36
13. In the distal forearm, use blunt dissection to separate the tendons of the **flexor digitorum superficialis muscle** from the tendons of the **flexor digitorum profundus muscle**.
14. Pull the tendons of the flexor digitorum superficialis anteriorly to free them from the carpal tunnel. *Note that during this procedure, the common flexor synovial sheath will be destroyed.*
15. Clean the surface of the tendons of the flexor digitorum superficialis muscle near the base of each digit.
16. In the palm, identify and clean the tendons of the **flexor digitorum profundus muscle**.
17. Follow the tendons of flexor digitorum profundus distally and observe the relationship of the four attached **lumbrical muscles**.

CLINICAL CORRELATION

### Carpal Tunnel Syndrome

ATLAS 2.74, 2.98

A common flexor sheath surrounds the tendons of the flexor digitorum profundus and superficialis, but not the tendon of the flexor pollicis longus as they pass through the carpal tunnel as shown in FIGURE B2.1. A swelling of the common flexor synovial sheath, commonly caused by repetitive movement, may encroach on the available space in the carpal tunnel resulting in compression of the contents. As a result of the swelling, the median nerve may be compressed resulting in pain and paresthesia of the thumb, index, and middle fingers and weakness of the thenar muscles.

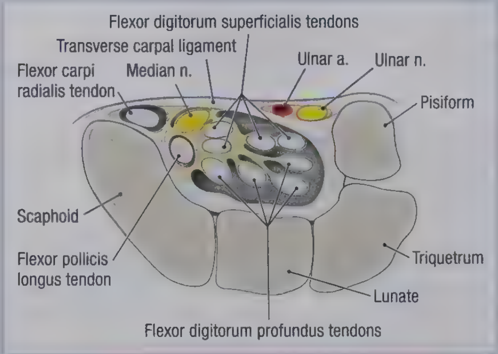

Flexor digitorum superficialis tendons
Transverse carpal ligament
Flexor carpi radialis tendon
Median n.
Ulnar a.
Ulnar n.
Pisiform
Scaphoid
Flexor pollicis longus tendon
Triquetrum
Lunate
Flexor digitorum profundus tendons

FIGURE B2.1 ■ Axial section through right carpal tunnel. Inferior view.

18. Clean the surface of the lumbricals but do not disrupt their points of attachment to flexor digitorum profundus.
19. Review the attachments and actions of the **flexor digitorum profundus muscle** and the **lumbricals** (see **TABLE 2.5** and **TABLE 2.6**).
20. Use a scalpel to carefully make a midline incision through the **fibrous digital sheath** on the flexor surface of at least one digit (**Cut 1**) and remove it from the digit.
21. Study the **relationship of the tendons of the flexor digitorum superficialis** and **flexor digitorum profundus muscles**. Verify that the flexor digitorum superficialis tendon attaches to the middle phalanx and that the flexor digitorum profundus tendon passes through the split distal end of the superficialis tendon and attaches to the distal phalanx for digits 2 to 5.
22. Identify the **flexor pollicis longus muscle** in the forearm and follow its tendon distally through the carpal tunnel into the palm. Pull on the tendon to confirm that the flexor pollicis longus muscle flexes the distal phalanx of the thumb.

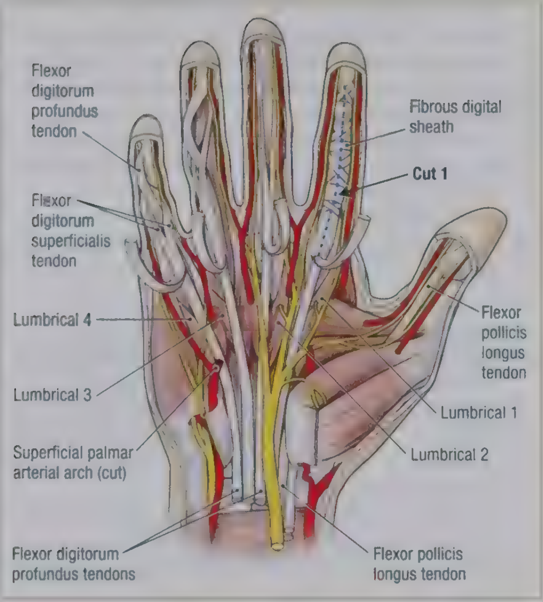

Flexor digitorum profundus tendon
Flexor digitorum superficialis tendon
Lumbrical 4
Lumbrical 3
Superficial palmar arterial arch (cut)
Flexor digitorum profundus tendons
Fibrous digital sheath
Cut 1
Flexor pollicis longus tendon
Lumbrical 1
Lumbrical 2
Flexor pollicis longus tendon

FIGURE 2.36 ■ Intermediate right palm. Anterior (palmar) view.

## Thenar Muscles

ATLAS 2.72A, 2.72B, 2.74; VIDEO 2.8.4

1. Refer to FIGURE 2.37.
2. Clean the thin layer of palmar fascia off the thenar muscles making an effort to preserve the recurrent branch of the median nerve.
3. Identify the two superficially located muscles of the thenar group: **abductor pollicis brevis** and **flexor pollicis brevis.**
4. Examine the **recurrent branch of the median nerve.**
5. Use a probe to follow the recurrent branch of the median nerve and separate the abductor pollicis brevis muscle from the flexor pollicis brevis muscle.
6. Use a probe to elevate the abductor pollicis brevis muscle and transect it and the flexor pollicis brevis with scissors near their distal attachments.
7. Observe the **opponens pollicis muscle** deep to the abductor and flexor pollicis brevis muscles. *Note that the opponens pollicis muscle attaches to the lateral side of the entire length of the shaft of the first metacarpal bone.*
8. Review the attachments and actions of the **thenar group of muscles** (see **TABLE 2.6**).

CLINICAL CORRELATION

### Recurrent Branch of the Median Nerve

ATLAS 2.71, 2.74

The recurrent branch of the median nerve is superficial and can easily be severed by "minor" cuts over the thenar eminence. If the recurrent branch of the median nerve is injured, the thenar muscles are paralyzed and the thumb cannot be opposed. Commonly, the recurrent branch of the median nerve is referred to as the thenar branch, or "the million-dollar nerve," due to its importance and potential value if severed.

## Hypothenar Muscles

ATLAS 2.72A, 2.74; VIDEO 2.8.5

1. Refer to FIGURE 2.37.
2. Clean the thin layer of palmar fascia off the hypothenar muscles.
3. Identify the three muscles of the hypothenar group: **abductor digiti minimi, flexor digiti minimi brevis,** and **opponens digiti minimi.**
4. Find the tendons of the abductor digiti minimi and flexor digiti minimi brevis muscles near their distal attachments on the base of the proximal phalanx of digit 5. Use a probe to separate and define the borders of the muscles along their tendons.
5. Review the attachments and actions of the **hypothenar group of muscles** (see **TABLE 2.6**).
6. Use a probe to elevate the abductor digiti minimi muscle and observe the underlying **opponens digiti minimi muscle.**
7. If the opponens digiti minimi is not visible, detach the abductor digiti minimi from its distal attachment and reflect the muscle toward its attachment on the flexor retinaculum. Preserve the deep branches of the ulnar artery and ulnar nerve.

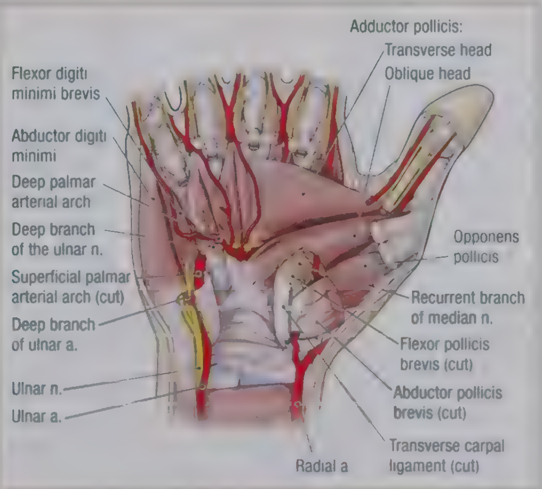

Adductor pollicis:
Transverse head
Oblique head
Flexor digiti minimi brevis
Abductor digiti minimi
Deep palmar arterial arch
Deep branch of the ulnar n.
Superficial palmar arterial arch (cut)
Deep branch of ulnar a.
Ulnar n.
Ulnar a.
Radial a
Opponens pollicis
Recurrent branch of median n.
Flexor pollicis brevis (cut)
Abductor pollicis brevis (cut)
Transverse carpal ligament (cut)

FIGURE 2.37 ■ Deep right palm. Anterior (palmar) view.

## Deep Palm

ATLAS 2.73, 2.77, 2.78; VIDEO 2.8.6

1. Refer to FIGURE 2.37.
2. Transect the flexor digitorum profundus muscle in the distal forearm proximal to the carpal tunnel.
3. Reflect the tendons of the flexor digitorum profundus and the associated lumbrical muscles distally as far as possible to expose the deep palm.
4. Find the ulnar nerve and the ulnar artery on the lateral side of the pisiform bone and identify the **deep branch of the ulnar nerve** and the **deep palmar branch of the ulnar** artery.
5. Follow the deep branches of the ulnar artery and nerve to the proximal attachments of the flexor digiti minimi brevis and abductor digiti minimi muscles.
6. Push a probe parallel to the deep branch of the ulnar nerve where it pierces the opponens digiti minimi muscle.
7. Use a scalpel to cut down to the inserted probe and release the branches of the ulnar nerve.
8. Use blunt dissection to follow the deep branch of the ulnar nerve laterally across the palm and observe that it lies on the anterior surface of the interosseous muscles then passes into the adductor pollicis muscle.
9. Identify the **deep palmar arterial arch** and observe that it arises from the **radial artery** laterally and the deep branch of the ulnar artery medially.
10. Identify the **palmar metacarpal** arteries and use an illustration to study the branches of the deep palmar arch.
11. Identify the **adductor pollicis muscle** in the deep palm and use blunt dissection to define its borders.
12. Identify the two heads of the adductor pollicis muscle: **oblique** and **transverse**.
13. Review the attachments and actions of the **adductor pollicis muscle** (see **TABLE 2.6**).
14. Refer to FIGURE 2.38.
15. Identify the three **palmar interosseous muscles** and observe their unipennate appearance.
16. The **dorsal interossei muscles** are bipennate muscles and will be seen on the dorsal surface of the hand occupying the intervals between the metacarpal bones, do not make attempts to dissect these muscles. *Note that dorsal interossei are considered intrinsic muscles of the palm of the hand despite their visibility on the dorsal surface.*
17. Observe that the three **P**almar interosseous muscles are **AD**ductors (**PAD**), which adduct digits 2, 4, and 5 toward an imaginary axial line drawn through the long axis of digit 3.
18. The four **D**orsal interosseous muscles are **AB**ductors (**DAB**), which move digits 2, 3, and 4 away from the imaginary axial line. The two dorsal interosseous muscles attaching to digit 3 move it to either side of the imaginary axial line back and forth. *Note that all of the interosseous muscles are innervated by the deep branch of the ulnar nerve.*

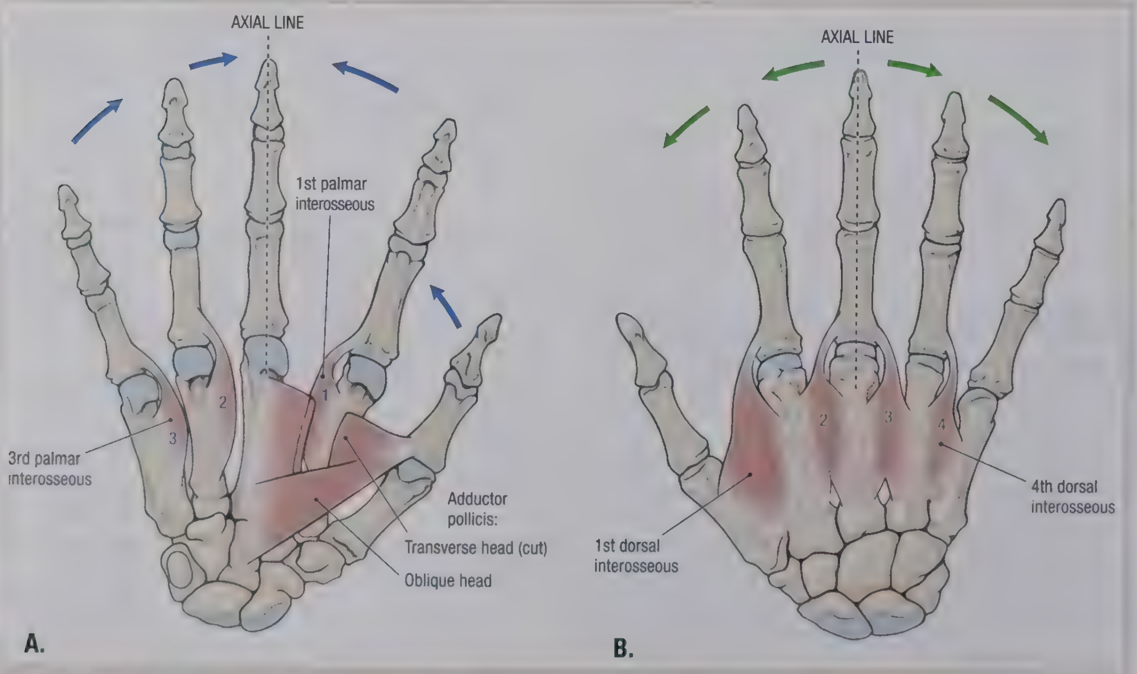


FIGURE 2.38 ■ **A.** Right palmar interossei muscles. Anterior (palmar) view. **B.** Dorsal interossei muscles. Posterior (dorsal) view.

## Dissection Follow-up

1. Review the movements of the fingers and thumb defining flexion, extension, abduction, and adduction while reviewing the muscles responsible for each using **TABLE 2.6**.
2. Review the path of the median nerve from the forearm into the hand and review its pattern of motor and cutaneous innervation including the distribution of its recurrent branch.
3. Review the path of the ulnar artery from the elbow to the hand tracing the superficial and deep palmar branches and review the formation of the palmar arterial arches.
4. Review the path of the ulnar nerve from posterior to the medial epicondyle of the humerus to the hand, trace its superficial and deep branches in the hand and review its pattern of motor and cutaneous distribution.
5. Place the dissected muscles, tendons, and nerves back into their correct anatomical positions.
6. Familiarize yourself with the cutaneous distribution of the ulnar and median nerves in the hand.

**TABLE 2.6 | Intrinsic Hand Muscles**

| | | | | |
|---|---|---|---|---|
| SUPERFICIAL PALM | | | | |
| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
| Palmaris brevis | Medial aspect of the palmar aponeurosis | Skin over the hypothenar eminence | Wrinkles skin of medial palm | Ulnar n. |
| THENAR GROUP OF MUSCLES | | | | |
| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
| Abductor pollicis brevis | Transverse carpal ligament and tubercle of scaphoid and trapezium | Lateral side, base of proximal phalanx of the thumb | Abducts the thumb | Recurrent branch of the median n. |
| Flexor pollicis brevis | | Volar side, base of proximal phalanx of the thumb | Flexes the thumb | |
| Opponens pollicis | | Lateral side of the shaft of the first metacarpal bone | Rotates the first metacarpal toward the palm | |
| HYPOTHENAR GROUP OF MUSCLES | | | | |
| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
| Abductor digiti minimi | Pisiform, hamate, and transverse carpal ligament | Medial side, base of the proximal phalanx of digit 5 | Abducts digit 5 | Deep branch of ulnar n. |
| Flexor digiti minimi brevis | | Volar side, base of the proximal phalanx of digit 5 | Flexes digit 5 | |
| Opponens digiti minimi | | Medial border of the fifth metacarpal bone | Rotates fifth metacarpal toward the palm | |
| DEEP PALM | | | | |
| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
| Lumbricals | Flexor digitorum profundus tendons | Radial side of the extensor expansions of digits 2–5 | Flexes MCP and extends PIP and DIP of digits 2–5 | 1 and 2—median n.; 3 and 4—deep branch of ulnar n. |
| Adductor pollicis muscle | Transverse head—anterior surface of the shaft of third metacarpal<br>Oblique head—second and third metacarpals and adjacent carpal bones | Medial side of base of proximal phalanx of thumb | Draws the thumb toward the plane of the palm (adduction) | Deep branch of ulnar n. |
| Palmar interossei | Palmar surface of metacarpals of digits 2, 4, and 5 | Base of the proximal phalanges and extensor expansion of digits 2, 4, and 5 | Adducts digits 2, 4, and 5 and assists lumbricals in MCP flexion and extension of PIP and DIP of digits 2–5 | |
| Dorsal interossei | Metacarpal bones 1–5 | Base of the proximal phalanges and the extensor expansion of digits 2–4 | Abducts digits 2–4 and assists lumbricals in MCP flexion and extension of PIP and DIP of digits 2–5 | |

Abbreviations: DIP, distal interphalangeal; MCP, metacarpophalangeal; n., nerve; PIP, proximal interphalangeal.

# EXTENSOR REGION OF THE FOREARM AND DORSUM OF THE HAND

## Dissection Overview

The posterior compartment of the forearm contains the extensor muscles of the hand and digits and can be divided into superficial and deep layers. The muscles of the superficial layer extend the wrist and the digits. The muscles of the deep layer cause supination of the forearm, extension of the index finger, and abduction and extension of the thumb. The nerves and vessels of the posterior compartment run in the connective tissue plane dividing the superficial and deep layers of extensor muscles.

In the dorsum of the hand, the skin is thinner and looser than the palm, intrinsic muscles are absent, and the bones are relatively superficial making them easily palpable. Because there are no intrinsic muscles in the dorsum of the hand, no motor innervation is required and the radial, ulnar, and median nerves share the cutaneous innervation.

The order of dissection will be as follows: The antebrachial fascia will be removed from the elbow to the wrist. The muscles of the superficial extensor layer will be identified and followed to their distal attachments in the hand. On the side where you did the deep dissection of the flexor muscles, the tendons of the superficial extensor muscles will be released from the extensor retinaculum and retracted to expose the muscles of the deep extensor layer. The contents and boundaries of the anatomical snuffbox will be studied.

## Dissection Instructions

### Cutaneous Nerves and Superficial Veins of the Posterior Forearm

ATLAS 2.4E, 2.5, 2.11B; VIDEO 2.9.1

1. Refer to FIGURE 2.39.
2. With the cadaver in the supine position, flex the elbow and rotate the upper limb to achieve increased visibility of the posterior compartment of the forearm, and then use string to hold it in this position or have a dissection partner assist in orienting the upper limb throughout the dissection.
3. Use blunt dissection to remove the remnants of the superficial fascia from the posterior forearm and dorsum of the hand, taking care to preserve the **dorsal venous arch** and its contributions to the **basilic** and **cephalic veins**.
4. Identify the **superficial branch of the radial nerve** and follow it onto the dorsum of the hand.
5. Identify the **dorsal cutaneous branch of the ulnar nerve** and follow it onto the dorsum of the hand.
6. Remove any remaining skin from the posterior aspect of the forearm and hand as well as the posterior surface of at least one digit.
7. Follow the dorsal venous network toward the digits and verify that the **dorsal digital veins** drain into this network on the dorsum of the hand.
8. Identify the **extensor retinaculum**, a transversely oriented specialization of the antebrachial fascia, on the posterior surface of the distal forearm.
9. Use scissors to incise the posterior surface of the **antebrachial fascia** from the olecranon to the wrist while preserving the extensor retinaculum (**Cut 1**).
10. Use blunt dissection to separate the antebrachial fascia from the underlying muscles, detach it from its attachments to the radius and ulna, and place it in the tissue container. *Note that in the proximal extensor forearm, the fascia will be hard to separate from the muscles and it may be necessary to use sharp dissection.*

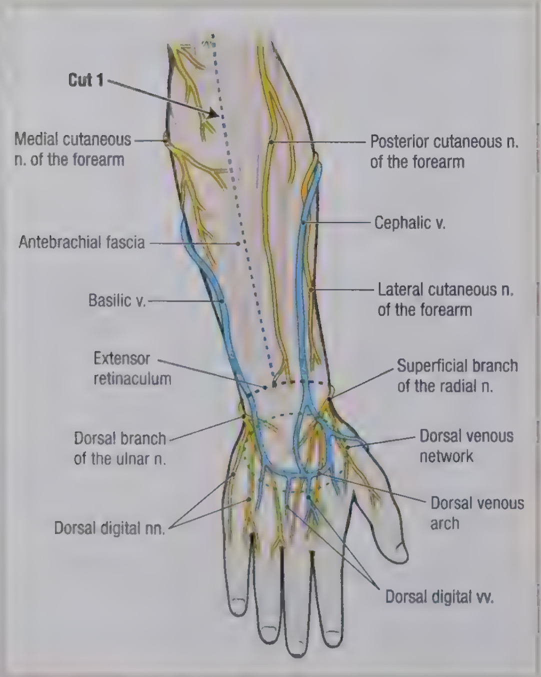

Cut 1
Medial cutaneous n. of the forearm
Posterior cutaneous n. of the forearm
Cephalic v.
Antebrachial fascia
Basilic v.
Lateral cutaneous n. of the forearm
Extensor retinaculum
Superficial branch of the radial n.
Dorsal branch of the ulnar n.
Dorsal venous network
Dorsal venous arch
Dorsal digital nn.
Dorsal digital vv.

FIGURE 2.39 • Superficial veins and cutaneous nerves of the posterior forearm and dorsum of hand. Posterior view.

### Superficial Layer of Extensor Muscles

ATLAS 2.83, 2.84A; VIDEO 2.9.2

1. Refer to FIGURE 2.40.
2. Identify and clean the **anconeus muscle** near the olecranon process of the ulna. Recall that the anconeus is a muscle of the posterior compartment of the arm and innervated by the radial nerve along with the triceps muscle.

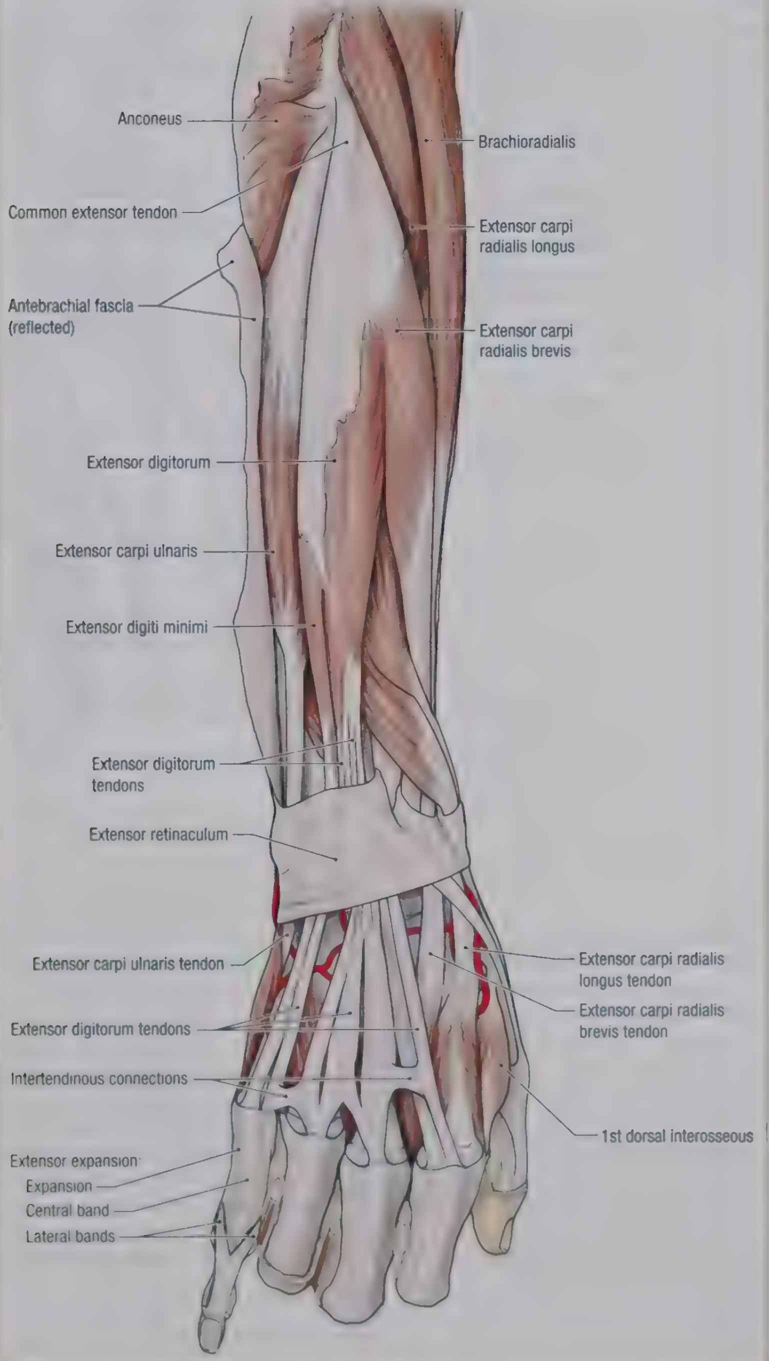

Anconeus
Common extensor tendon
Antebrachial fascia (reflected)
Extensor digitorum
Extensor carpi ulnaris
Extensor digiti minimi
Extensor digitorum tendons
Extensor retinaculum
Extensor carpi ulnaris tendon
Extensor digitorum tendons
Intertendinous connections
Extensor expansion:
Expansion
Central band
Lateral bands
Brachioradialis
Extensor carpi radialis longus
Extensor carpi radialis brevis
Extensor carpi radialis longus tendon
Extensor carpi radialis brevis tendon
1st dorsal interosseous

FIGURE 2.40 • Superficial layer of extensor (posterior compartment) muscles in the right forearm. Posterior (dorsal) view.

3. Review the attachments and actions of the **anconeus muscle** (see **TABLE 2.7**).
4. Identify and clean the **brachioradialis** on the lateral aspect of the forearm. Recall that the brachioradialis muscle originates in the posterior compartment of the arm and forms the lateral border of the cubital fossa.
5. Adjacent to the brachioradialis muscle, identify and clean the **extensor carpi radialis longus** and the **extensor carpi radialis brevis muscles**.
6. In the middle of the posterior forearm, identify and clean the **extensor digitorum muscle**.
7. Observe that the extensor digitorum splits distally into four tendons that pass deep to the **extensor retinaculum** to reach digits 2 to 5. *Note that all of the extensor tendons travel across the dorsal wrist deep to the extensor retinaculum within osseofibrous tunnels. As on the flexor side, the tendons are enveloped in synovial tendon sheaths.*
8. Observe that the tendons of the extensor digitorum muscle are connected to each other by **intertendinous connections** on the posterior surface of the hand near the MCP joints.
9. Identify and clean the **extensor digiti minimi muscle** on the ulnar side of the extensor digitorum muscle belly. *Note that the extensor digiti minimi muscle sends two tendons distally to digit 5.*
10. On the ulnar side of the forearm, identify and clean the **extensor carpi ulnaris muscle**.
11. Note that four of the muscles in the superficial extensor layer (extensor carpi radialis brevis, extensor digitorum, extensor digiti minimi, and extensor carpi ulnaris) originate on the lateral epicondyle of the humerus by way of a **common extensor tendon**.
12. Review the attachments, actions, and innervations of the **superficial layer of extensor muscles** (see **TABLE 2.7**).
13. Refer to FIGURE 2.41.
14. Identify the **extensor expansion** on the dorsum of the digits on which the skin was removed. Observe that the "hoodlike" expansion retains the extensor tendon in the midline of the digit.
15. On the peripheral sides of a skinned digit, observe that the extensor expansion wraps around the dorsum and sides of the proximal phalanx and distal end of the metacarpal bone.
16. Turn the palm and follow the tendon of a lumbrical muscle to the extensor expansion and verify that it attaches from the flexor digitorum profundus tendon into the extensor expansion proximally.
17. Follow the tendon of an interossei muscle to the extensor expansion and verify that it also attaches into the extensor expansion.
18. Observe that the extensor expansion continues across both the PIP and DIP joints to insert on the base of the distal phalanx.
19. Gently pull on the extensor digitorum tendon and verify that pulling on the extensor expansion results in extension of both the PIP and DIP joints; thus, contraction of the extensor digitorum, the lumbricals, or the interossei will all result in extension of the digit at the PIP and DIP joint.
20. On the palmar surface of the digit, retract the tendons of the **flexor digitorum superficialis** and **profundus** away from the phalanges and observe that the tendons are anchored to the bone by short and long extensions from the synovial sheaths of the digit, the **vincula brevia** and **vincula longa**, respectively. *Note that the vincula longa and breva are the primary route of blood vessels to supply the distal portion of the flexor tendons.*

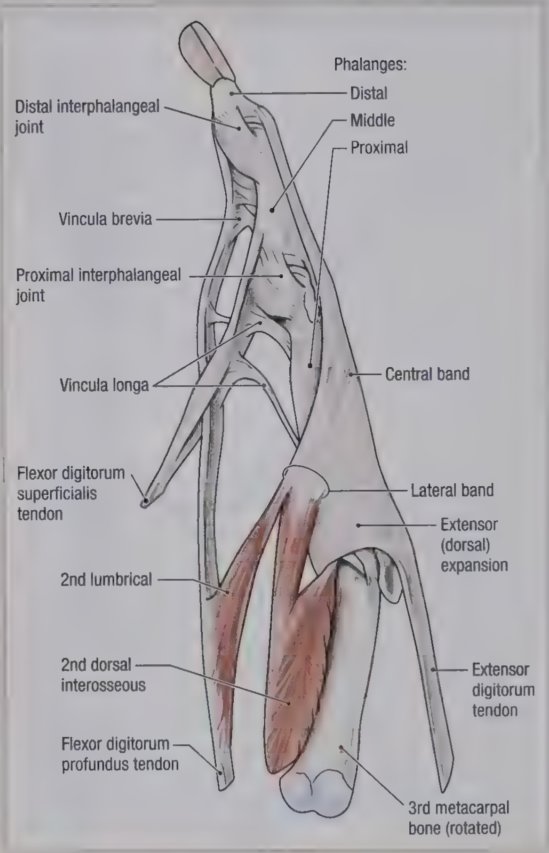

Phalanges:
Distal
Middle
Proximal
Distal interphalangeal joint
Vincula brevia
Proximal interphalangeal joint
Vincula longa
Central band
Flexor digitorum superficialis tendon
Lateral band
Extensor (dorsal) expansion
2nd lumbrical
2nd dorsal interosseous
Extensor digitorum tendon
Flexor digitorum profundus tendon
3rd metacarpal bone (rotated)

FIGURE 2.41 ■ Extensor expansion of the right third digit. Lateral view.

## Deep Layer of Extensor Muscles

ATLAS 2.84B; VIDEO 2.9.3

***Dissection Note:*** Perform the following dissection sequence only on one upper limb.

1. Refer to FIGURE 2.42.
2. On the upper limb with the deep flexor dissections, cut through the **extensor retinaculum** to

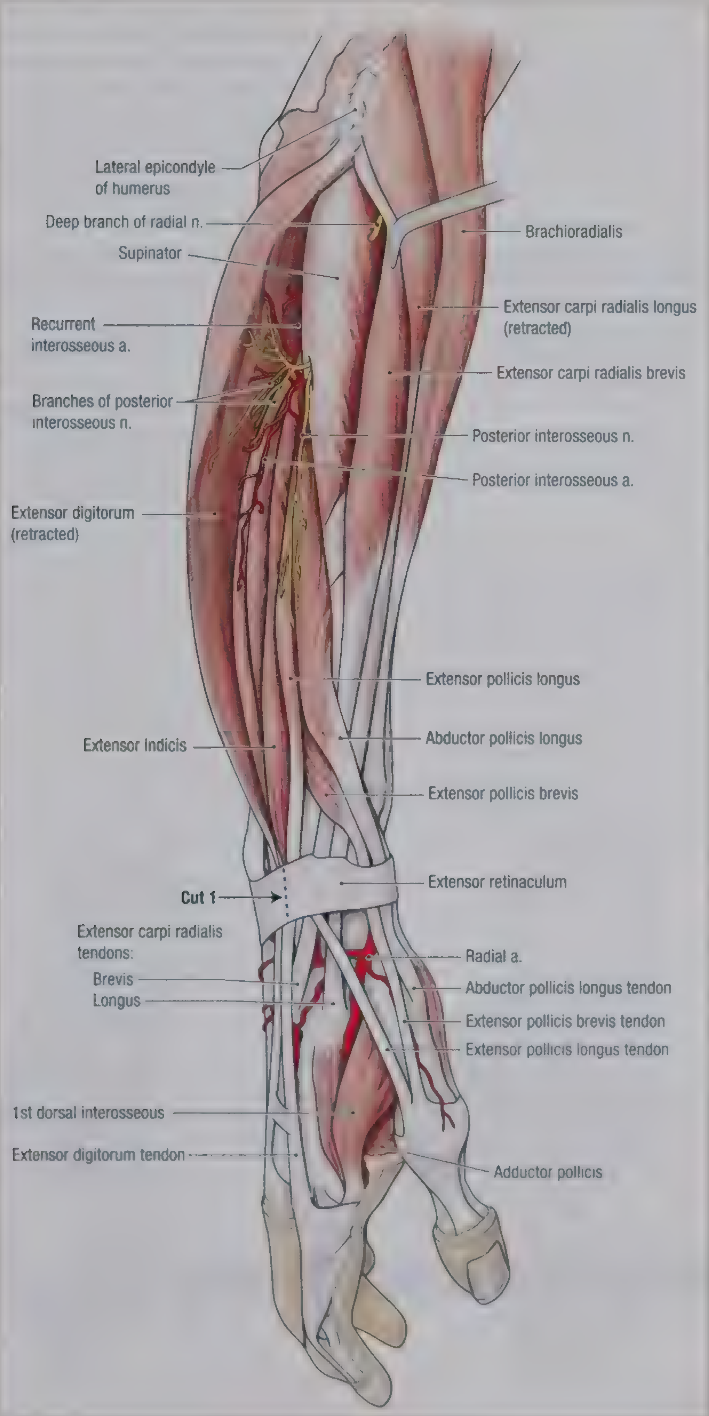

Lateral epicondyle of humerus
Deep branch of radial n.
Supinator
Recurrent interosseous a.
Branches of posterior interosseous n.
Extensor digitorum (retracted)
Extensor indicis
Cut 1
Extensor carpi radialis tendons:
Brevis
Longus
1st dorsal interosseous
Extensor digitorum tendon
Brachioradialis
Extensor carpi radialis longus (retracted)
Extensor carpi radialis brevis
Posterior interosseous n.
Posterior interosseous a.
Extensor pollicis longus
Abductor pollicis longus
Extensor pollicis brevis
Extensor retinaculum
Radial a.
Abductor pollicis longus tendon
Extensor pollicis brevis tendon
Extensor pollicis longus tendon
Adductor pollicis

FIGURE 2-42 ■ Deep layer of extensor (posterior compartment) muscles in the right forearm. Lateral view.

release the tendons of the extensor digitorum muscle (**Cut 1**).

3. Use blunt dissection to separate the superficial layer of extensor muscles from the five muscles comprising the **deep layer of extensor muscles**.
4. Near the elbow, retract the brachioradialis muscle and observe the **supinator muscle** wrapped around the proximal end of the radius.
5. On the lateral aspect of the elbow, find the radial nerve in the connective tissue plane between the brachioradialis muscle and the brachialis muscle. Observe that the radial nerve divides into a superficial branch and a deep branch. The **deep branch of the radial nerve** enters the supinator muscle.
6. Look for the deep branch of the radial nerve where it emerges from the distal border of the supinator muscle. *Note that at this point, the deep branch of the radial nerve becomes the* ***posterior interosseous nerve****.*
7. Observe that the posterior interosseous nerve is accompanied by the **posterior interosseous artery**, a branch of the common interosseous artery.
8. Identify and clean the **abductor pollicis longus**, **extensor pollicis brevis**, and **extensor pollicis longus muscles**. Observe that the tendons of these three muscles emerge from the interval between the extensor digitorum muscle and the extensor carpi radialis brevis muscle. For this reason, these deep muscles are often referred to as the "outcropping" muscles of the thumb.
9. Use blunt dissection to identify and clean the **extensor indicis muscle** lying deep to the extensor digitorum muscle. *Note that its tendon travels in the fourth dorsal compartment with the tendons of the extensor digitorum muscle.*
10. Review the attachments, actions, and innervations of the **deep layer of extensor muscles** (see **TABLE 2.7**).
11. Refer to FIGURE 2.43.
12. Identify the **anatomical snuffbox**, a depression on the posterolateral surface of the wrist bounded laterally by the **abductor pollicis longus** and the **extensor pollicis brevis tendons** and posteriorly by the **extensor pollicis longus tendon**.
13. Within the anatomical snuffbox, identify the **radial artery**.
14. Use blunt dissection to clean the radial artery and follow it distally until it disappears between the two heads of the **first dorsal interosseous muscle**. *Note that the* ***dorsal carpal arch*** *supplies arterial blood to the dorsum of the hand and receives a branch of the radial artery that arises in the anatomical snuffbox.* Do not dissect its branches.

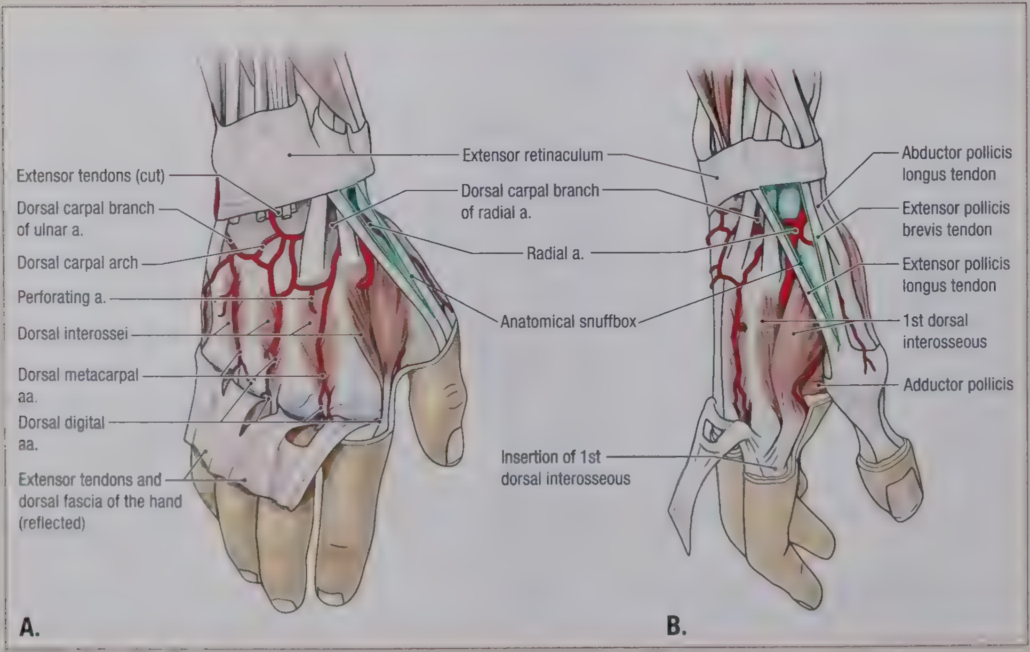

Extensor tendons (cut)
Dorsal carpal branch of ulnar a.
Dorsal carpal arch
Perforating a.
Dorsal interossei
Dorsal metacarpal aa.
Dorsal digital aa.
Extensor tendons and dorsal fascia of the hand (reflected)
Extensor retinaculum
Dorsal carpal branch of radial a.
Radial a.
Anatomical snuffbox
Insertion of 1st dorsal interosseous
Abductor pollicis longus tendon
Extensor pollicis brevis tendon
Extensor pollicis longus tendon
1st dorsal interosseous
Adductor pollicis
A.
B.

FIGURE 2.43 ■ A. Dorsum of right hand. Posterior (dorsal) view. **B.** Anatomical snuffbox. Lateral view.

## Dissection Follow-up

1. Review the actions and attachments of each muscle in the posterior compartment of the forearm in **TABLE 2.7**.
2. Review the muscles that insert into the extensor expansion and the actions of each.
3. Review the course of the common interosseous branch of the ulnar artery and its branches.
4. Review the boundaries and contents of the anatomical snuffbox noting the path of the radial artery from the cubital fossa to the deep palmar arterial arch via this space.
5. Review the path and pattern of motor and cutaneous innervation of the radial nerve.
6. Replace the muscles of the posterior compartment of the forearm into their correct anatomical positions.

**TABLE 2.7 | Posterior Compartment of the Forearm**

| SUPERFICIAL GROUP OF MUSCLES | | | | |
|---|---|---|---|---|
| ***Muscle*** | ***Proximal Attachments*** | ***Distal Attachments*** | ***Actions*** | ***Innervation*** |
| Anconeus | Lateral epicondyle of humerus | Lateral surface of olecranon and posterior surface of proximal ulna | Assists triceps in extension of the elbow | Radial n. |
| Brachioradialis | Proximal two-thirds of lateral supracondylar ridge | Lateral surface of distal radius (radial styloid process) | Flexes the forearm in neutral (midpronated) position | |
| Extensor carpi radialis longus | Distal lateral supracondylar ridge | Base of second metacarpal | Extends and abducts the hand | Radial n. |
| Extensor carpi radialis brevis | Lateral epicondyle of humerus via common extensor tendon | Base of third metacarpal | | Deep branch of radial n. |
| Extensor digitorum | | Extensor expansions of digits 2–5 | Extends digits 2–5 | Posterior interosseous n. |
| Extensor digiti minimi | | Extensor expansion of digit 5 | Extends fifth digit | |
| Extensor carpi ulnaris | | Base of fifth metacarpal | Extends and adducts the hand | |
| DEEP GROUP OF MUSCLES | | | | |
| ***Muscle*** | ***Proximal Attachments*** | ***Distal Attachments*** | ***Actions*** | ***Innervation*** |
| Supinator | Lateral epicondyle of humerus, radial collateral and annular ligaments, crest of ulna | Lateral, posterior, and anterior surfaces of proximal ulna | Supinates forearm | Deep branch of the radial n. |
| Abductor pollicis longus | Posterior surfaces of the radius, ulna, and interosseous membrane | Base of first metacarpal | Abducts and extends CMC of thumb | Posterior interosseous n. |
| Extensor pollicis brevis | | Base of the proximal phalanx of digit 1 | Extends MCP of thumb | |
| Extensor pollicis longus | | Base of the distal phalanx of digit 1 | Extends MCP and IP of thumb | |
| Extensor indicis | | Extensor expansion of digit 2 | Extends digit 2 | |

Abbreviations: CMC, carpometacarpal joint; IP, interphalangeal joint; MCP, metacarpophalangeal joint; n., nerve.

# JOINTS OF THE UPPER LIMB

## Dissection Overview

In order to dissect the joints in the upper limb, it will be necessary to reflect or remove the majority of the surrounding muscles. Because the joint dissections will make it difficult to review key muscular relationships later, it is recommended to limit the joint dissections to one upper limb and to keep the soft tissue structures of the other limb intact for review purposes. While removing the muscles of the selected upper limb, take advantage of this opportunity to review the attachments, actions, and innervation of each muscle as it is removed.

The order of dissection will be as follows: The sternoclavicular and AC joints will be dissected. The glenohumeral joint will be dissected. The elbow joint and radioulnar joints will be studied. The wrist joint will be dissected. Finally, the joints of the digits will be studied.

## Dissection Instructions

***Dissection Note:*** Perform the following joint dissections only on one upper limb, preferably the side where the deeper dissections of the forearm occurred previously.

### Sternoclavicular Joint

ATLAS 2.44A; VIDEO 2.10.1

1. Refer to FIGURE 2.44.
2. On an articulated skeleton, identify the **jugular notch of the manubrium** between the **medial (sternal) ends of the clavicles.**
3. With the cadaver in the supine position, identify the **sternoclavicular joint.** Observe that the clavicles articulate with the manubrium at each **clavicular notch** and the adjacent part of the **first costal cartilage.**
4. Observe that the tendon of the **sternocleidomastoid muscle** is attached to the anterior surface of the sternoclavicular joint.
5. Identify and clean the **anterior sternoclavicular ligament,** which spans from the sternum to the clavicle.
6. Identify and clean the **costoclavicular ligament,** which runs obliquely from the first costal cartilage to the inferior surface of the clavicle near its medial end.
7. Use a scalpel to remove the anterior sternoclavicular ligament to expose the joint cavity.
8. Identify the **articular disc** within the joint cavity. Observe that inferiorly, the articular disc is attached to the first costal cartilage, whereas superiorly, it is attached to the clavicle. *Note that the articular disc is attached in such a manner that it resists medial displacement of the clavicle.*
9. Palpate the movements of the sternoclavicular joint either on yourself or the cadaver. Circumduct the upper limb and observe that the sternoclavicular joint allows a limited amount of movement in every direction.

### Acromioclavicular Joint

ATLAS 2.44, 2.46B; VIDEO 2.10.2

1. Refer to FIGURE 2.45.
2. On an articulated skeleton, identify the **AC joint.** Observe that the AC joint is located where the **lateral (acromial) end of the clavicle** articulates with the **acromion of the scapula.**
3. Inferomedial to the acromion, identify the **coracoid process of the scapula** and note its proximity to the **suprascapular notch.**
4. Detach the trapezius muscle from the lateral end of the clavicle and supraclavicular fascia superiorly if it was previously not done.
5. Detach the coracobrachialis muscle from its attachment to the coracoid process and reflect it laterally.
6. Detach the pectoralis minor muscle from its attachment to the coracoid process and reflect it inferiorly. If the pectoralis minor muscle was previously detached from its inferior attachment to the ribs, remove the muscle and place it in the tissue container.
7. Identify the AC joint, a plane synovial joint between the acromion and the lateral end of the clavicle.

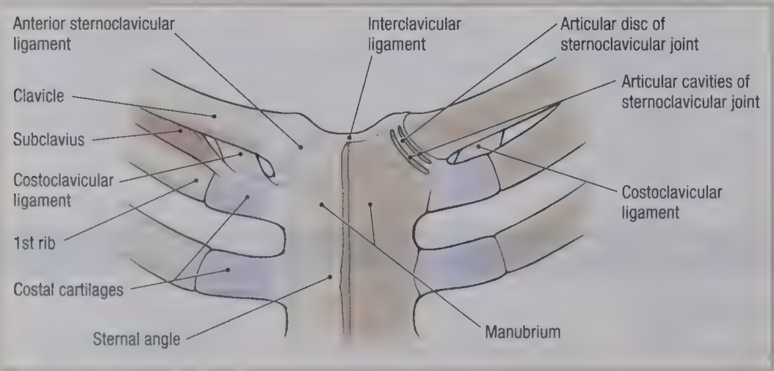


FIGURE 2.44 ■ Surface (*right*) and sectional (*left*) views of sternoclavicular joints. Anterior view.

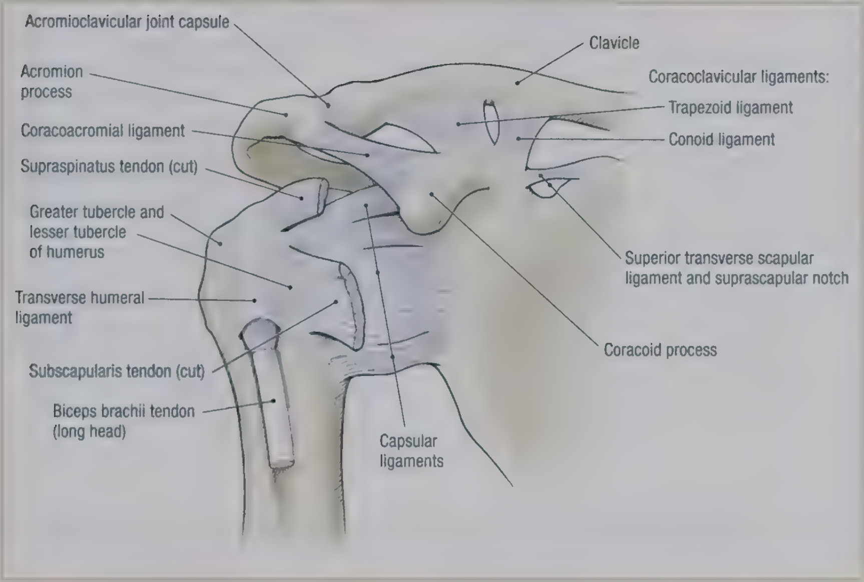

Acromioclavicular joint capsule
Acromion process
Coracoacromial ligament
Supraspinatus tendon (cut)
Greater tubercle and lesser tubercle of humerus
Transverse humeral ligament
Subscapularis tendon (cut)
Biceps brachii tendon (long head)
Capsular ligaments
Clavicle
Coracoclavicular ligaments:
Trapezoid ligament
Conoid ligament
Superior transverse scapular ligament and suprascapular notch
Coracoid process

FIGURE 2.45 ● Right acromioclavicular and glenohumeral joints. Anterior view.

8. Identify and clean the **coracoclavicular ligament** located between the clavicle and coracoid process. Observe that the coracoclavicular ligament has two parts that help support the AC joint. Identify the more laterally located **trapezoid ligament** and the more medially located **conoid ligament**.
9. Open the AC joint by completely removing the joint capsule.
10. Separate the acromion from the lateral end of the clavicle and observe the shape of the articulating surfaces. Note that the angle of the articulating surfaces causes the acromion to slide inferior to the distal end of the clavicle when the acromion is forced medially. The conoid and trapezoid ligaments prevent the acromion from moving inferiorly relative to the clavicle, thus strengthening the joint.

## Glenohumeral Joint

ATLAS 2.46A, 2.46C; VIDEO 2.10.3

1. Refer to FIGURE 2.45.
2. On an articulated skeleton, identify the **glenohumeral (shoulder) joint** and observe that it is the articulation between the **glenoid fossa of the scapula** and the **head of the humerus**.
3. Identify the **anatomical neck of the humerus** and note its oblique orientation distal to the smooth articulating surface of the head of the humerus.
4. With the cadaver in the supine position, cut the anterior attachment of the deltoid to clavicle and reflect the muscle laterally.
5. Reflect the pectoralis major muscle laterally and make an incision through its tendon near the attachment to the intertubercular sulcus. Cut any adhering neurovascular structures and place the muscle and associated tissue in the tissue container.
6. Detach the short head of the biceps brachii muscle from the coracoid process.
7. Cut the tendon of the long head of the biceps approximately 3 cm inferior to the transverse humeral ligament. Reflect the biceps brachii muscle inferiorly.
8. Cut through the proximal attachment of the coracobrachialis muscle, detach any adhering neurovascular structures and reflect the muscle inferiorly.
9. Define and clean the **coracoacromial ligament**, which spans from the coracoid process to the acromion. *Note that the coracoacromial ligament, the acromion, and the coracoid process prevent superior displacement of the head of the humerus.*
10. Elevate and cut the tendons of the supraspinatus and subscapularis muscles near their lateral attachments.
11. Identify the **capsule of the glenohumeral joint** and remove the muscles and tendons overlying the capsule on its superior and anterior surfaces.

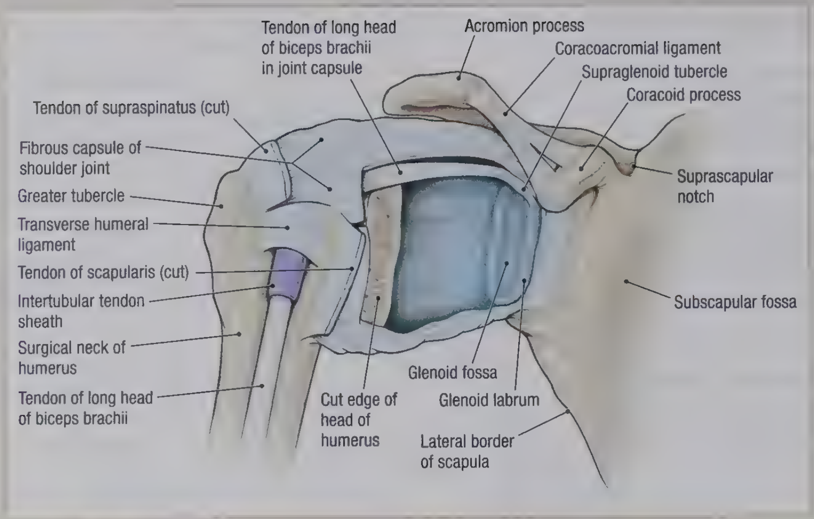

Tendon of long head of biceps brachii in joint capsule
Acromion process
Coracoacromial ligament
Supraglenoid tubercle
Coracoid process
Tendon of supraspinatus (cut)
Fibrous capsule of shoulder joint
Greater tubercle
Transverse humeral ligament
Tendon of scapularis (cut)
Intertubular tendon sheath
Surgical neck of humerus
Tendon of long head of biceps brachii
Suprascapular notch
Subscapular fossa
Glenoid fossa
Cut edge of head of humerus
Glenoid labrum
Lateral border of scapula

FIGURE 2.46 Opened glenohumeral joint with removed head of the humerus. Anterior view.

12. Verify that the joint capsule is attached to the anatomical neck of the humerus. Recall that posteriorly, the tendons of the infraspinatus and teres minor muscles blend with and reinforce the joint capsule.
13. Observe that the **glenohumeral ligament** strengthens the anterior wall of the fibrous capsule. The glenohumeral ligament can be divided into three portions: superior, middle, and inferior, which are not easily identifiable.
14. Refer to FIGURE 2.46.
15. Use a scalpel to carefully open the anterior surface of the joint capsule by making an oblique cut medial to the anatomical neck of the humerus.
16. Within the capsule, identify the **tendon of the long head of the biceps brachii muscle** and observe that the tendon passes through the glenoid cavity to attach to the supraglenoid tubercle.
17. Observe the relative thickness of the capsule and make horizontal incisions or remove portions of the capsule to increase visibility within the space, while sparing the biceps tendon.
18. Abduct and rotate the upper limb to increase visibility of the humeral head and use a saw or a chisel to remove the head of the humerus at the anatomical neck. Make an effort to preserve the attachment of the capsule while removing the humeral head.
19. Use a probe to explore the **glenoid cavity** and identify the **glenoid labrum**.
20. Use the dissected specimen to perform the movements of the glenohumeral joint: flexion, extension, abduction, adduction, and rotation. *Note that this freedom of motion is obtained at the loss of joint stability.*

**CLINICAL CORRELATION**

### Joint Injuries (Dislocated and Separated Shoulder)

ATLAS 2.46, 2.47

The glenohumeral (shoulder) joint has a greater degree of movement than any other joint in the body and is thus prone to injury because the mobility comes at the cost of stability. Shoulder dislocations, a complete separation of the head of the humerus from the glenoid fossa, commonly occur inferiorly between the gap in rotator cuff muscles to lie either anterior or posterior to the infraglenoid tubercle and long head of the triceps. Subluxations, temporary displacements of the humeral head, are also common at the shoulder. A blow to the superior aspect of the shoulder may lead to a dislocation, or a separated shoulder, which is displacement of the acromial end of the clavicle with the acromion process at the AC joint.

## Elbow and Proximal Radioulnar Joints

ATLAS 2.55, 2.56, 2.57; VIDEO 2.10.4

1. Refer to FIGURE 2.47.
2. On an articulated skeleton, verify that the elbow joint consists of three bones and three distinct joints that allow flexion and extension as well as pronation and supination.
3. Identify the **hinge joint** between the trochlea of the humerus and the trochlear notch of the ulna.

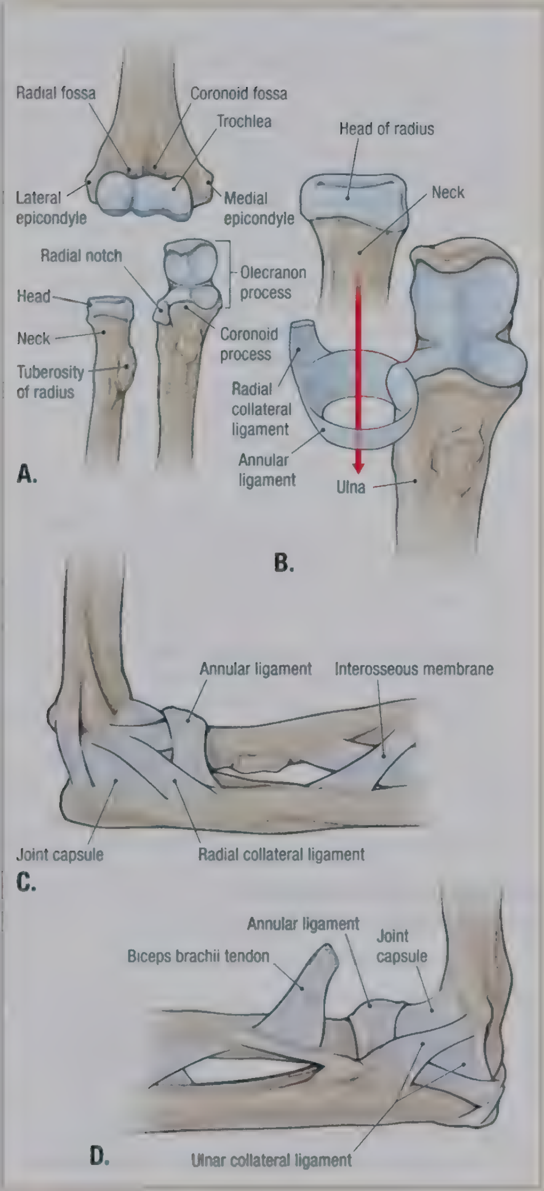

Radial fossa
Coronoid fossa
Trochlea
Lateral epicondyle
Medial epicondyle
Radial notch
Head
Neck
Tuberosity of radius
Olecranon process
Coronoid process
A.
Head of radius
Neck
Radial collateral ligament
Annular ligament
Ulna
B.
Annular ligament
Interosseous membrane
Joint capsule
Radial collateral ligament
C.
Annular ligament
Biceps brachii tendon
Joint capsule
D.
Ulnar collateral ligament

FIGURE 2.47 ● **A.** Disarticulated right elbow. **B.** Disarticulated proximal radioulnar joint. Anterior views. Ligaments of the right elbow **C.** Lateral view. **D.** Medial view.

4. Identify the **gliding joint** between the capitulum of the humerus and the head of the radius.
5. Identify the **pivot joint** between the head of the radius and the radial notch of the ulna.
6. With the cadaver in the supine position, cut the biceps brachii tendon where it crosses the cubital fossa and reflect the muscle superiorly.
7. Remove the brachialis muscle from the anterior surface of the joint capsule.
8. Rotate the upper limb either laterally or medially and detach the triceps brachii tendon from the olecranon and the posterior surface of the joint capsule and reflect the muscle superiorly.
9. If all the joint dissections are being performed on one upper limb, increase the mobility and decrease the weight of the upper limb by removing the bulk of the triceps brachii muscle and placing it in the tissue container.
10. Cut and detach the superficial flexor muscles of the forearm by cutting through their attachment to the medial epicondyle via the common flexor tendon and reflect the muscles inferiorly.
11. Identify the **ulnar collateral ligament** on the medial side of the elbow joint and observe that it consists of a strong anterior cord and a fanlike posterior portion.
12. Cut the brachioradialis muscle proximally near its attachment to the lateral supracondylar ridge and reflect the muscle inferiorly.
13. Cut and reflect the superficial extensor muscles of the forearm by cutting through their attachment to the lateral epicondyle of the humerus.
14. Take a moment to observe the attachments of the supinator muscle. Observe its role in supination while actively pronating and supinating the forearm. Recall that the biceps brachii muscle also supinates the forearm by pulling on the radial tuberosity while the forearm is pronated.
15. Detach the supinator from its proximal and distal attachments and place it in the tissue container.
16. Identify the **radial collateral** ligament and observe that it fans out from the lateral epicondyle of the humerus to the **annular ligament**.
17. On an articulated skeleton, verify that the **proximal radioulnar joint** is a pivot joint between the head of the radius and the radial notch of the ulna.
18. On the cadaver, identify and clean the **annular ligament**.
19. Actively pronate and supinate the forearm and observe that the head of the radius can freely rotate in the annular ligament. *Note that the annular ligament completely encircles the head of the radius along with the radial notch of the ulna.*
20. Open the elbow joint by making a transverse cut through the anterior surface of the joint capsule between the ulnar and the radial collateral ligaments.
21. Use a probe to explore the extent of the **synovial cavity**. Observe the smooth articular surfaces of the humerus, ulna, and radius.
22. Use the dissected specimen to perform the movements of the elbow joint: flexion and extension, pronation and supination. Observe the joint surfaces and the collateral ligaments during these movements.

## Intermediate and Distal Radioulnar Joints

ATLAS 2.60B, 2.68; VIDEO 2.10.5

1. Refer to FIGURE 2.48.
2. The radius and ulna are joined along their length by the **interosseous membrane** creating a strong fibrous (syndesmosis) joint.
3. In the forearm, identify the interosseous membrane and observe its attachments along the interosseous margins of the radius and ulna.
4. Observe that the interosseous membrane does not connect to the elbow but has a gap proximally allowing for passage of the nerves and vessels from the anterior compartment of the forearm to the posterior compartment.
5. On an articulated skeleton, observe that the distal radioulnar joint is a pivot joint between the head of the ulna and the ulnar notch of the radius.
6. Verify that the **wrist joint (radiocarpal joint)** is the articulation between the distal end of the **radius** and the proximal row of **carpal bones**. The wrist is a condyloid joint and allows for movement in two planes: flexion/extension in the sagittal plane and abduction/adduction in the coronal plane.
7. Observe that the proximal row of carpal bones articulates with the radius proximally at the wrist and that the distal row of carpal bones articulates distally at the carpometacarpal joint. The articulation between the two rows of carpal bones is the **midcarpal joint**.
8. In the anterior compartment of the forearm, remove all the tendons and soft tissue structures crossing the wrist. Review the distal attachments, actions, and innervations of each muscle during removal.
9. Observe that the anterior and posterior surfaces of the wrist joint are reinforced by the **radiocarpal ligaments**. *Note that each ligament is named according to its specific sites of attachment.*
10. Extend the wrist and cut transversely through the radiocarpal ligaments on the anterior surface of the joint capsule proximal to the transverse carpal ligament and carpal tunnel. Do not cut completely through the joint capsule; rather, leave the hand attached to the forearm posteriorly.
11. Use a probe to explore the distal radioulnar joint and identify the joint space between the radius and ulna.
12. Identify the **articular surface of the radius** on its distal end and verify that it articulates with the **scaphoid** and **lunate** carpal bones.
13. Identify the smooth proximal surfaces of the **scaphoid**, **lunate**, and **triquetrum**. *Note that the **scaphoid** and **lunate** bones are positioned to transmit forces from the hand to the forearm and therefore are the ones most commonly fractured in a fall on the outstretched hand.*
14. Identify the **articular disc of the wrist**. Verify that the articular disc holds the distal ends of the radius and the ulna together and articulates with the triquetrum when the hand is adducted.
15. Use the dissected specimen to perform the movements of the wrist joint: flexion, extension, adduction, abduction, and circumduction. Observe the articular surfaces during these movements.

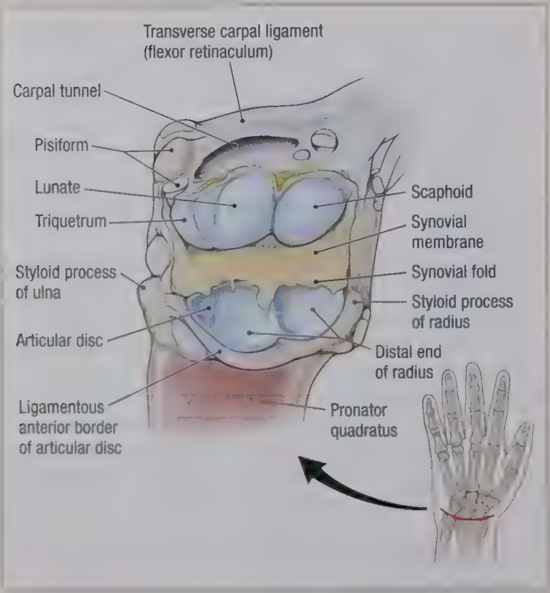


FIGURE 2.48 ● Disarticulated right radiocarpal joint. Anterior view.

## Metacarpophalangeal and Interphalangeal Joints

ATLAS 2.87, 2.94; VIDEO 2.10.6

1. Refer to FIGURE 2.49.
2. On an articulated skeleton, identify the **MCP joints**. Confirm that the MCP joints are condyloid joints like the wrist and support flexion/extension and abduction/adduction.
3. Identify the **PIP** and **DIP** joints of digits 2 to 5 and the interphalangeal (IP) joint of the thumb. Confirm that the IP joints are hinge joints and allow only flexion and extension.
4. Select a digit to use as a representative example for the other digits.
5. Cut the attachments of the flexor digitorum superficialis from the middle phalanx and the flexor digitorum profundus muscle from the distal phalanx.
6. Remove the interosseous muscles, lumbrical, and the extensor expansion to expose the MCP joint capsule.
7. Identify and clean the **collateral ligaments of the MCP joint**.

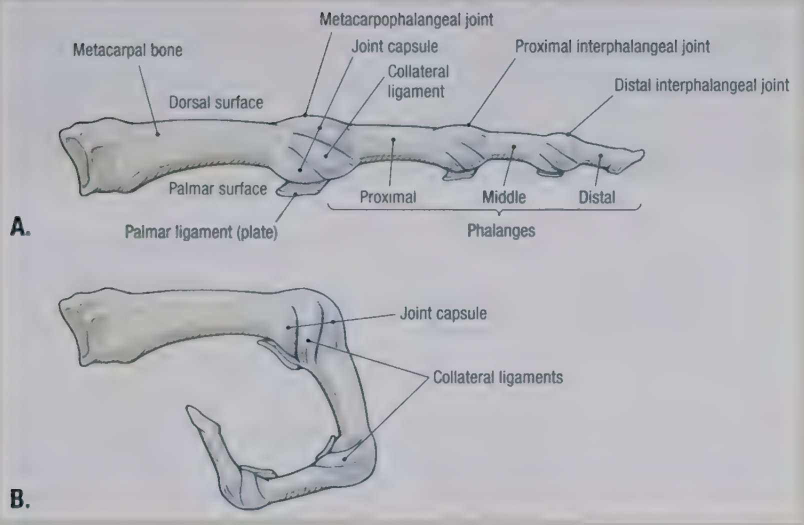

Metacarpophalangeal joint
Metacarpal bone
Joint capsule
Collateral ligament
Proximal interphalangeal joint
Distal interphalangeal joint
Dorsal surface
Palmar surface
Proximal
Middle
Distal
A.
Palmar ligament (plate)
Phalanges
Joint capsule
Collateral ligaments
B.

FIGURE 2.49 ■ Metacarpophalangeal and interphalangeal joints of right third digit in extension (A) and flexion (B). Medial view.

8. Move the digit to confirm that the collateral ligaments are slack during extension and taut during flexion. Therefore, the digits cannot be spread (abducted) unless they are extended.
9. Use the dissected specimen to perform the movements of the digit at the MCP joint: flexion, extension, abduction, and adduction.
10. Identify and clean the **collateral ligaments of the IP joints** of the selected digit.
11. Use a scalpel to make an incision along the anterior surface of one PIP joint.
12. Use a probe to explore the synovial cavity of the IP joint and inspect the articular surfaces covered with smooth cartilage.
13. Identify the **volar plate**, a fibrocartilaginous extension of the base of the middle phalanx.
14. Use the dissected specimen to perform flexion and extension of the IP joints and confirm that the collateral ligaments limit the range of motion.

## Dissection Follow-up

1. Review the names of the bones articulating at each joint of the upper limb.
2. Review the movements permitted at each joint of the upper limb.
3. Identify the key ligaments associated with each joint and review their respective points of attachment.
4. Return the reflected muscles of the upper limb back to their anatomical positions.

## CHAPTER 3

# The Thorax

**REFERENCES**

ATLAS = *Grant's Atlas of Anatomy*, 15th ed., figure number

VIDEO = *Grant's Dissection Videos*, video sequence number

The main function of the thorax is to house and protect the fragile vital organs of the heart and lungs. The protective function of the thoracic wall is combined with mobility to accommodate volume changes during ventilation. These two dissimilar functions, protection and mobility, are accomplished by the alternating arrangement of the ribs and intercostal muscles.

To allow communication with the vital organs, the thorax has two apertures that allow the passage of structures either superiorly or inferiorly. Structures pass between the thorax, the neck and head, and the upper limb through the superior thoracic aperture (e.g., trachea, esophagus, vagus nerves, thoracic duct, and major blood vessels).

The diaphragm attaches to the structures forming the boundaries of the inferior thoracic aperture and separates the thoracic and abdominal cavities. Several large structures (e.g., aorta, thoracic duct, inferior vena cava, esophagus, and vagus nerves) pass between the thorax and abdomen through openings in the diaphragm.

**CLINICAL CORRELATIONS**

During the course of your dissection protocol, you may encounter anatomical variations, clinical conditions, disease processes, or medical devices in your cadaveric donor. The following select clinical correlations are described in more detail throughout this chapter.

**The Thorax**

1. Surgical Access through the Anterior Thoracic Wall, see the **Anterior Thoracic Wall** sequence. ATLAS 3.21
2. Pleural Cavity (Pneumothorax, Pleural Effusion, Hemothorax), see the **Pleural Cavities** sequence. ATLAS 3.27
3. Pericardium (Pericardial Effusion, Hemopericardium, Cardiac Tamponade), see the **Heart in the Thorax** sequence. ATLAS 3.28
4. Myocardial Infarction (MI), see the **Surface Features and Valves of the Removed Heart** sequence. ATLAS 3.46
5. Coronary Arteries (Heart Dominance), see the **Coronary Arteries** sequence. ATLAS 3.50, 3.51
6. Fossa Ovalis, see the **Right Atrium** sequence. ATLAS 3.54
7. Left Recurrent Laryngeal Nerve, see the **Superior Mediastinum** sequence. ATLAS 3.60, 3.74
8. Bifurcation of the Trachea, see the **Superior Mediastinum** sequence. ATLAS 3.63

## PECTORAL REGION

The superficial fascia of the pectoral region contains the usual elements that are common to superficial fascia in all body regions: blood vessels, lymph vessels, cutaneous nerves, and sweat glands. In addition, the superficial fascia of the anterior thoracic wall contains the mammary glands, which are highly specialized organs unique to the superficial fascia of the thorax.

If the thorax is your first dissection, or if you have not yet completed dissection of the upper limb, place the cadaver in a supine position and follow the dissection protocols outlined in Chapter 2 for **Pectoral Region and Superficial Fascia of the Upper Limb**. Following completion of the muscles of the pectoral region, leave the cadaver in a supine position and return to this page.

# INTERCOSTAL SPACE AND INTERCOSTAL MUSCLES

## Dissection Overview

The interval between adjacent ribs is called the intercostal space. The intercostal space is truly a space only in a skeleton because three layers of muscle and neurovascular structures fill the intercostal spaces in the body. From superficial to deep, the three layers of muscle are external intercostal muscle, internal intercostal muscle, and innermost intercostal muscle. There are 11 intercostal spaces on each side of the thorax, and each is numbered according to the rib that forms its superior boundary.

The order of dissection will be as follows: The skeletal anatomy of the ribs and thoracic cage will be studied. The surface anatomy of the pectoral region will be reviewed. The external intercostal muscle will be studied in the fourth intercostal space and will be reflected. The internal intercostal muscle will be studied in the fourth intercostal space and reflected. Branches of intercostal nerves and blood vessels will be identified. The innermost intercostal muscle will be identified.

### Skeletal Anatomy

Refer to a skeleton or isolated ribs and sternum and identify the following skeletal features.

#### Rib

ATLAS 3.12, 3.14

1. Refer to FIGURE 3.1.
2. On an isolated **6th** or **7th rib**, identify the **head** and **neck of the rib**, and observe that the head of the rib has **articular facets (surfaces)**.
3. Lateral to the neck of the rib, identify the **tubercle**, a bony prominence on its inferior surface, and note that it also has an **articular facet (surface)**.
4. Lateral to the tubercle, observe where the rib changes direction along the **shaft (body)** at the **costal angle**, as well as the **costal groove** along its inferior surface.
5. Identify the **sternal end** of the rib, the distal extremity of the bone.
6. Refer to FIGURE 3.2.
7. On an articulated skeleton, observe that the **head** of a rib usually articulates with two vertebral bodies and their intervertebral (IV) disc. For example, the head of rib 5 articulates with vertebral bodies T4 and T5. *Note that the 1st, 10th, 11th, and 12th ribs are exceptions to this rule because their heads articulate with only one vertebral body.*
8. Identify the **tubercle** of a rib and observe that it articulates with the **transverse costal facet** on the transverse process of the thoracic vertebra of the same number.
9. Inferior to the articulation of the rib and transverse process, identify an **IV foramen** and note that the corresponding spinal nerve would exit through this space inferior to the corresponding rib.
10. Recall that the IV foramen is formed by aspects from two adjacent vertebrae: the **inferior vertebral notch** from the more superiorly located vertebra and the **superior vertebral notch** from the more inferiorly located vertebra.

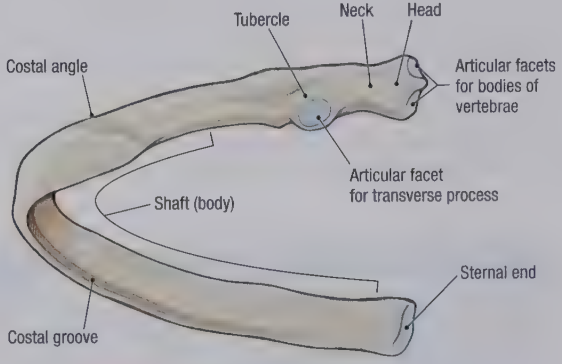

Tubercle
Neck
Head
Costal angle
Articular facets for bodies of vertebrae
Articular facet for transverse process
Shaft (body)
Sternal end
Costal groove

FIGURE 3.1 ● Typical left rib. Posterior view.

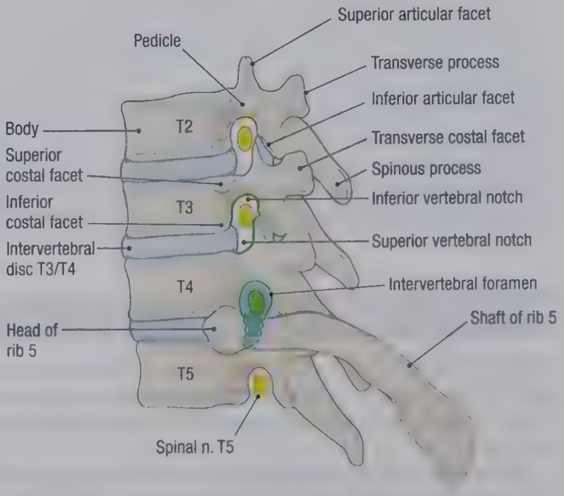

Superior articular facet
Pedicle
Transverse process
Inferior articular facet
Body
T2
Transverse costal facet
Superior costal facet
Spinous process
Inferior costal facet
T3
Inferior vertebral notch
Intervertebral disc T3/T4
Superior vertebral notch
T4
Intervertebral foramen
Head of rib 5
Shaft of rib 5
T5
Spinal n. T5

FIGURE 3.2 ● Portion of thoracic vertebral column (T2–T5). Lateral view.

### Sternum and Clavicle

ATLAS 3.10A, 3.11

1. Refer to FIGURE 3.3.
2. On the sternum, identify the **manubrium**, the **body of the sternum**, and the **xiphoid process**.
3. Examine the **sternum** and observe that the **sternal angle** is at the level of the **second costal cartilage** anteriorly and the level of the **T4/T5 IV disc** posteriorly.
4. On a clavicle, identify the **medial (sternal) end** and the **lateral (acromial) end**.
5. On an articulated skeleton, identify the **jugular notch** (suprasternal notch), the space between the two sternal ends of the clavicles where they articulate with the manubrium of the sternum forming the bilateral **sternoclavicular (SC) joints**.
6. Observe that the lateral end of the clavicle articulates with the **acromion of the scapula** to create the **acromioclavicular (AC) joint** laterally.

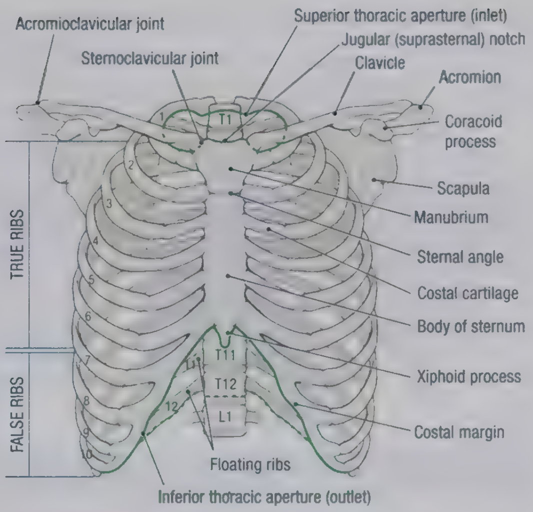


FIGURE 3.3 ● Thoracic skeleton. Anterior view.

### Thoracic Cage

ATLAS 3.10

1. Refer to FIGURE 3.3.
2. Identify the **superior thoracic aperture (thoracic inlet)** and observe that it is bounded completely by bone.
3. Identify the boundaries of the superior thoracic aperture: anteriorly by the superior portion of the manubrium of the sternum, laterally by the right and left first ribs, and posteriorly by the body of vertebra T1.
4. Identify the **inferior thoracic aperture (thoracic outlet)** and observe that it is larger than the superior thoracic aperture.
5. Identify the boundaries of the inferior thoracic aperture: anteriorly by the xiphisternal joint and the costal margin, laterally by ribs 11 and 12, and posteriorly by the body of vertebra T12.
6. Anteriorly along the lateral aspect of the **sternum**, observe that **costal cartilage** is attached to the anterior end of some ribs. *Note that ribs are classified by the way their costal cartilages articulate medially.*
7. Identify the **true ribs (ribs 1 to 7)**, in which the costal cartilages articulate directly to the sternum.
8. Identify the **false ribs (ribs 8 to 12)**, in which the costal cartilages articulate with the costal cartilage of the rib above, as seen along the **costal margin**.
9. Identify the two **false or floating ribs (ribs 11 and 12)**, which do not articulate anteriorly with a skeletal element but end in the abdominal musculature.
10. Observe how the ribs angle inferiorly approximately two vertebral levels as they wrap laterally and anteriorly around the thorax.
11. Observe that the **first rib** is the highest, shortest, broadest, and most sharply curved rib.

## Dissection Instructions

### Intercostal Space and Intercostal Muscles

ATLAS 3.17, 3.18; VIDEO 3.1.1

1. Refer to FIGURE 3.4.
2. Turn the cadaver to the supine position and palpate the jugular notch (suprasternal notch) on the superior aspect of the manubrium between the sternal ends of the clavicles.
3. Palpate the inferior extent of the **sternocleidomastoid (SCM) muscle**, a large diagonally oriented muscle of the neck attaching to either side of the jugular notch. Observe that the SCM has two heads inferior, a **clavicular head** attaching to the clavicle, and a **sternal head** attaching to the manubrium of the sternum.
4. Deep and medial to the SCM, identify the inferior extent of the infrahyoid (strap) muscles, which attach to the superior extent of the mediastinum along its deep surface.
5. Palpate the sternal angle (manubriosternal junction) between the manubrium and **body of the sternum** and confirm that it is at the height of the **2nd costal cartilage**.

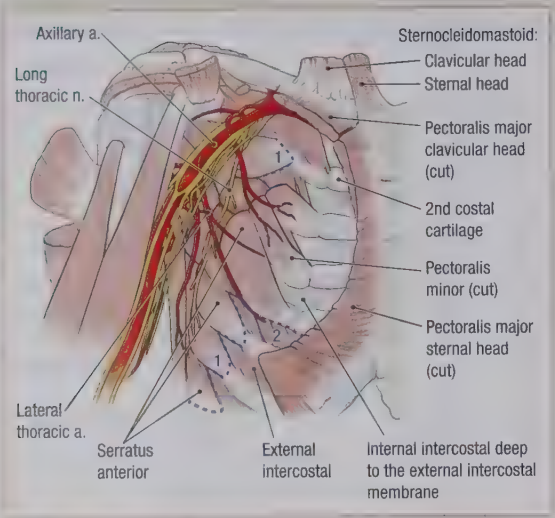

Axillary a.
Long thoracic n.
Sternocleidomastoid:
Clavicular head
Sternal head
Pectoralis major clavicular head (cut)
2nd costal cartilage
Pectoralis minor (cut)
Pectoralis major sternal head (cut)
1
2
1
Lateral thoracic a.
Serratus anterior
External intercostal
Internal intercostal deep to the external intercostal membrane

FIGURE 3.4 ● External aspect of right anterior thoracic wall. Anterior view.

6. Inferior to the body of the sternum, palpate the **xiphoid process** just below the **xiphisternal junction** and progress bilaterally along the **costal margins** noting the cut medial attachments of the pectoralis major as you do so.
7. Palpate the ribs and the intercostal spaces beginning at the level of the sternal angle (attachment of the second costal cartilage) and identify each intercostal space by number.
8. Use a scalpel to remove any remaining muscular tissue of the **clavicular** and **sternal heads of the pectoralis major muscle** along the inferior aspect of the clavicle and lateral aspects of the sternum bilaterally.
9. Remove any remaining muscular tissue of the **pectoralis minor** attaching to the ribs.
10. Identify the **serratus anterior muscle**, the **lateral thoracic artery** arising from the **axillary artery**, and the **long thoracic nerve**.
11. Detach the **serratus anterior muscle**, one attachment at a time, from its proximal attachments on the upper eight or nine ribs (**Cut 1**).
12. Reflect the serratus anterior muscle, along with the long thoracic nerve and lateral thoracic artery, laterally.
13. Identify the **external intercostal muscle** in intercostal space 4 or 5. Observe that the fibers of the external intercostal muscle course from superolateral to inferomedial.
14. Identify the **external intercostal membrane** located at the anterior end of the intercostal space, between the **costal cartilages**.
15. Observe that the fibers of the external intercostal muscle end at the lateral edge of the external intercostal membrane.
16. Insert a probe deep to the external intercostal membrane lateral to the border of the sternum in the fifth intercostal space and push the probe laterally deep to the external intercostal membrane and muscle.
17. With the probe as a guide, use scissors to cut the external intercostal membrane and muscle from the rib above and reflect them inferiorly (**Cut 2**). Continue the cut laterally toward the midaxillary line.
18. Identify the **internal intercostal muscle** and observe that the fibers course superomedial to inferolateral, perpendicular to the fiber direction of the external intercostal muscle.
19. Observe that the internal intercostal muscle fibers occupy the intercostal space all the way to the sternum and are visible deep to the external intercostal membrane.
20. Refer to FIGURE 3.5.
21. Begin at the lateral border of the sternum and detach the internal intercostal muscle from the rib above. Continue to detach the internal intercostal muscle as far laterally as the midaxillary line and reflect the muscle superiorly.
22. Look for the fourth **intercostal nerve** and the fourth **posterior intercostal artery and vein** inferior to rib 4. Observe that the intercostal nerve and vessels run in the plane between the **internal intercostal muscle** and **innermost intercostal muscle**.
23. Deep to the intercostal neurovascular structures, identify the **innermost intercostal muscle** and observe that it has the same fiber direction as the internal intercostal muscle but does not extend as far anteriorly in the intercostal space.

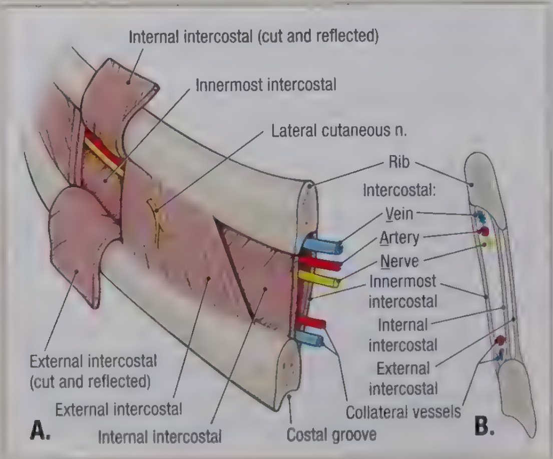

Internal intercostal (cut and reflected)
Innermost intercostal
Lateral cutaneous n.
Rib
Intercostal:
Vein
Artery
Nerve
Innermost intercostal
Internal intercostal
External intercostal
Collateral vessels
External intercostal (cut and reflected)
External intercostal
A.
Internal intercostal
Costal groove
B.

FIGURE 3.5 ● **A.** Intercostal muscles and contents of intercostal space. **B.** Coronal section of adjacent ribs and intercostal space at midaxillary line. Anterior views.

## Dissection Follow-up

1. Review the muscles of the intercostal space along with their respective actions in **TABLE 3.1**.
2. Review the origin, course, and branches of the posterior intercostal artery and intercostal nerve.
3. Replace the internal and external intercostal muscles in their correct anatomical positions.
4. Consult a dermatome chart and compare the dermatome pattern to the distribution of the intercostal nerves.

**TABLE 3.1 | Intercostal Muscles**

| *Muscle* | *Superior Attachment* | *Inferior Attachment* | *Actions* | *Innervation* |
|---|---|---|---|---|
| External intercostal | Inferior border of the rib above | Superior border of the rib below | Elevates the rib below | Intercostal nn. |
| Internal intercostal | | | Depresses the rib above | |
| Innermost intercostal | | | | |

Abbreviation: nn., nerves.

# ANTERIOR THORACIC WALL AND PLEURAL CAVITIES

## Dissection Overview

The body cavities (thoracic, pericardial, abdominal, and pelvic) are lined by regionally named serous membranes, which secrete a small amount of fluid to lubricate the movements of organs. In the thoracic cavity, there is bilayer serous membrane around the lungs (pleura), and the heart (pericardial). The parietal pleura lines the inner surfaces of the thoracic wall, the superior aspect of the diaphragm, and the centrally located mediastinum, while the visceral pleura covers the surfaces of the lungs. Between the two layers of pleura is a potential space called the pleural cavity.

The thorax contains two pleural cavities (right and left) and the mediastinum. The pleural cavities occupy the lateral aspect of the thoracic cavity and contain one lung each. The mediastinum, the region between the two pleural cavities, contains the heart and other contents of the thorax. To view the contents of the thoracic cavity, the anterior thoracic wall must be removed.

The order of dissection will be as follows: The SCM and infrahyoid neck muscles will be detached from the sternum and clavicle. The clavicles will be cut at their midpoint. The costal cartilages and sternum will be cut at the level of the xiphisternal joint. The ribs and intercostal structures will be cut at the midaxillary line. The anterior thoracic wall will be removed along with the associated costal parietal pleura. The inner surface of the thoracic wall and contents of the pleural cavities will be studied.

## Dissection Instructions

***Dissection Note:*** Various techniques may be implemented to expose the thoracic contents, two of which will be outlined here. The first creates a smaller window into the thoracic cage, whereas the second removes the entire anterior thoracic wall. In addition to removal of the ribs and muscles of the anterior thoracic wall, the costal pleura attached to its inner surface, as well as some key vascular branches, will be removed.

### Window through the Thoracic Wall

ATLAS 3.21, 3.24; VIDEO 3.2.1

***Dissection Note:*** The window technique preserves the relationships of the root of the neck superiorly and the thoracic outlet inferiorly. Removal of the lungs and dissection of the mediastinum, however, is more difficult due to the smaller region of access, and the bones may need to be cut further to increase visibility.

1. Refer to FIGURE 3.6A.
2. Reflect the pectoralis major muscle laterally, the pectoralis minor muscle superiorly, and the serratus anterior muscle laterally.
3. Use the bone saw to make a horizontal incision midway between the jugular notch and the sternal angle through the manubrium (**Cut 1**). *Note that for all cuts using the bone saw, you must only allow the saw to pass through the bone and cartilage but not into the deeper tissues within the thorax.*
4. At the level of the xiphisternal joint (approximately at the level of intercostal space 5), use the bone saw to make a transverse cut across the sternum and costal cartilages (**Cut 2**).
5. Continue the saw cut bilaterally, approximately 4 cm superior to the inferior border of the costal margin following the curve of the margin inferolaterally (**Cut 3**).
6. Using scissors, make a horizontal cut through the muscles to the midaxillary line at approximately intercostal space 8 (**Cut 4**).

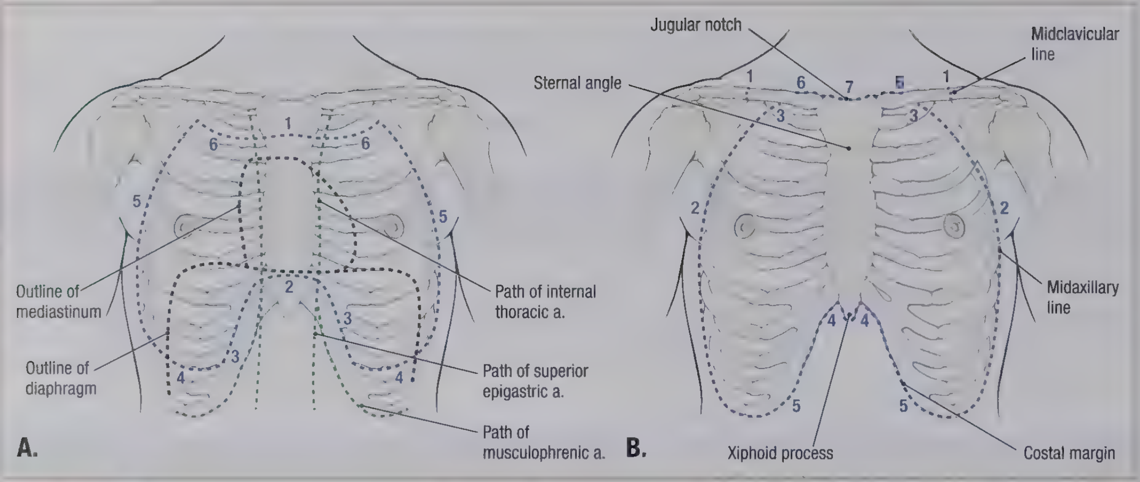


FIGURE 3.6 Removal of anterior thoracic wall. **A.** Smaller window through thoracic wall. **B.** Full anterior thoracic wall removal. Anterior views.

7. Use a saw or bone cutters to cut ribs 2 to 8 in the midaxillary line on both sides of the thorax beginning inferiorly and progressing superiorly (**Cut 5**). Elevate the cut portion of ribs or push against the cut rib one at a time to verify you have cut completely through each rib.
8. With a scalpel or scissors, make a series of vertical cuts through the muscles in intercostal spaces 1 to 8 in the midaxillary line. The cuts should be aligned with the cut ribs and deep enough to cut the parietal pleura but not the surface of the lungs.
9. Use scissors to cut through the muscles within the 1st intercostal space from the vertical cut along the midaxillary line to the horizontal cut through the manubrium (**Cut 6**).
10. Gently elevate the inferior end of the cut sternum along with the attached portions of the costal cartilages and ribs and reflect the anterior thoracic wall superiorly.
11. Near the inferior end of the sternum, identify the **right and left internal thoracic vessels**, and if they have not already been severed, use scissors to cut them at the level of the fifth intercostal space.
12. Continue to elevate the inferior end of the anterior thoracic wall and use scissors to cut any adhesions of parietal pleura from the inner surface of the thoracic wall onto the mediastinum.
13. Cut the internal thoracic vessels at the level of the first rib.
14. Remove the anterior thoracic wall along with the attached portions of the internal thoracic vessels.

## Removal of the Anterior Thoracic Wall

ATLAS 3.21, 3.24; VIDEO 3.2.2

***Dissection Note:*** Removing the entire anterior thoracic wall makes lung removal and mediastinal dissection easier and begins the transition into both the neck and abdomen. A full removal of the anterior thoracic wall does, however, disrupt some relationships of the root of the neck because it requires cutting the clavicles and the inferior extent of multiple neck muscles, and the anterior border of the diaphragm and muscles of the anterior abdominal wall must be cut as well.

1. Refer to FIGURE 3.6B.
2. Reflect the pectoralis major muscle laterally, the pectoralis minor muscle superiorly, and the serratus anterior muscle laterally.
3. Use a probe to gently push the contents of the axilla away from the inferior aspect of the clavicle.
4. Use a saw to cut both clavicles at their midpoint (**Cut 1**). *Note that for all cuts using the bone saw, you must only allow the saw to pass through the bone and cartilage but not into the deeper tissues within the thorax.*
5. Use a saw or bone cutters to cut ribs 2 to 8 in the midaxillary line on both sides of the thorax (**Cut 2**), beginning inferiorly and progressing superiorly. Elevate the cut portion of ribs or push against the cut rib one at a time to verify you have cut completely through each rib.
6. Palpate the first rib and use blunt dissection to push the contents of the axilla away from the rib.
7. Use the saw or bone cutters to cut through the first rib near the costal cartilage (**Cut 3**). While making the cut, pay attention to not damage any of the neurovascular structures passing into the axilla, in particular the subclavian vein.
8. With a scalpel or scissors, make a series of vertical cuts through the muscles in intercostal spaces 1 to 8 in the midaxillary line. The cuts should be aligned with the cut ribs and deep enough to cut the parietal pleura but not the surface of the lungs.

***Dissection Note:*** The inferior cuts in this approach may either replicate steps 4 through 6 as described in the **Window through the Thoracic Cage** approach, or steps 9 through 13 below.

9. Elevate the superior attachment of the rectus abdominis muscle with a probe.
10. Using the probe as a guide, transect the rectus abdominis muscle horizontally superior to the curve of the costal margin (**Cut 4**).
11. Continue the cut following the costal margin through the anterolateral abdominal wall muscles until you reach the midaxillary line (**Cut 5**). *Note that care must be taken to not cut too deeply and thus enter the abdominal cavity.*
12. Gently elevate the inferior end of the sternum along with the attached portions of the costal cartilages and ribs superiorly, and identify the muscular fibers of the diaphragm attaching along its deep surface.
13. Use a scalpel to trace along the curve of the costal margin to detach the diaphragm from its deep surface.
14. Near the inferior end of the sternum, identify the **right and left internal thoracic vessels**. If they have not already been severed, use scissors to cut the internal thoracic vessels at the level of the fifth intercostal space.
15. Continue to elevate the inferior end of the anterior thoracic wall using scissors to cut any adhesions of parietal pleura from the inner surface of the thoracic wall reflecting posteriorly onto the mediastinum.
16. Cut the internal thoracic vessels at the level of the first rib.
17. Detach the two heads of the SCM muscle from the superior margin of the sternum and the superior surface of the clavicle (**Cut 6**).
18. Use blunt dissection to loosen the distal 5 cm of the SCM muscle and reflect it superiorly.
19. Use your fingers or a probe to push the **infrahyoid muscles** posteriorly. Follow the infrahyoid muscles inferiorly and detach them from the deep surface of the sternum (**Cut 7**).
20. Remove the anterior thoracic wall along with the attached portions of the internal thoracic vessels.

## Anterior Thoracic Wall

ATLAS 3.22; VIDEO 3.2.3

1. Refer to FIGURE 3.7.
2. Identify the **costal parietal pleura** on the internal surface of the anterior thoracic wall.
3. Peel off a portion of the costal parietal pleura from the inner surface of the anterior thoracic wall and note the distinct tearing sound as you separate the pleura from the thoracic wall. The sound is the tearing of the fibers of the **endothoracic fascia**, the loose connective tissue attaching the costal parietal pleura to the thoracic wall.
4. Identify the **transversus thoracis muscle** on the deep surface of the sternum and costal cartilages. Observe that the inferior attachment of the transversus thoracis muscle is on the sternum, and its superior attachments are on costal cartilages 2 to 6.
5. Identify the **manubrium**, **body**, and **xiphoid process** of the sternum from the posterior.

### CLINICAL CORRELATION

**Surgical Access through the Anterior Thoracic Wall**

ATLAS 3.21

In thoracic surgery, the anterior and lateral approaches to the contents of the thorax are the two most common approaches. In the anterior approach, the sternum is split vertically in the midline to avoid any major vessels and allow for good access to the heart. The incision through the sternum is closed with stainless steel wires. In the lateral approach, an intercostal space is incised to provide access to the lungs or structures posterior to the heart.

6. Identify and clean the **internal thoracic artery** and **veins** between the transversus thoracis muscle and the costal cartilages.
7. Follow the internal thoracic artery inferiorly and identify at least one of its **anterior intercostal branches**.
8. Observe that **anterior intercostal arteries** arise from the internal thoracic artery to supply the anterior aspect of the intercostal space. *Note that the posterior aspect of the intercostal space is supplied by* ***posterior intercostal arteries****, which arise directly from the thoracic aorta to create an anastomosis with the anterior intercostal branches.*
9. Observe that posterior to the sixth or seventh costal cartilage, the internal thoracic artery terminates by dividing into the **superior epigastric artery** and the **musculophrenic artery**.
10. Study the course and distribution of a typical intercostal nerve and note that it supplies the intercostal muscles, the skin of the thoracic wall, and the parietal pleura.
11. If a full anterior thoracic wall approach was implemented, identify the cut edge of the **diaphragm** inferiorly, and the cut edges of the two visible **infrahyoid muscles**, the **sternothyroid** and the **sternohyoid**.

## Pleural Cavities

ATLAS 3.24, 3.27; VIDEO 3.2.4

1. Refer to FIGURE 3.8.
2. Use your hands to carefully explore the right and left pleural cavities paying attention because the cut ends of the ribs are sharp and can cut you.

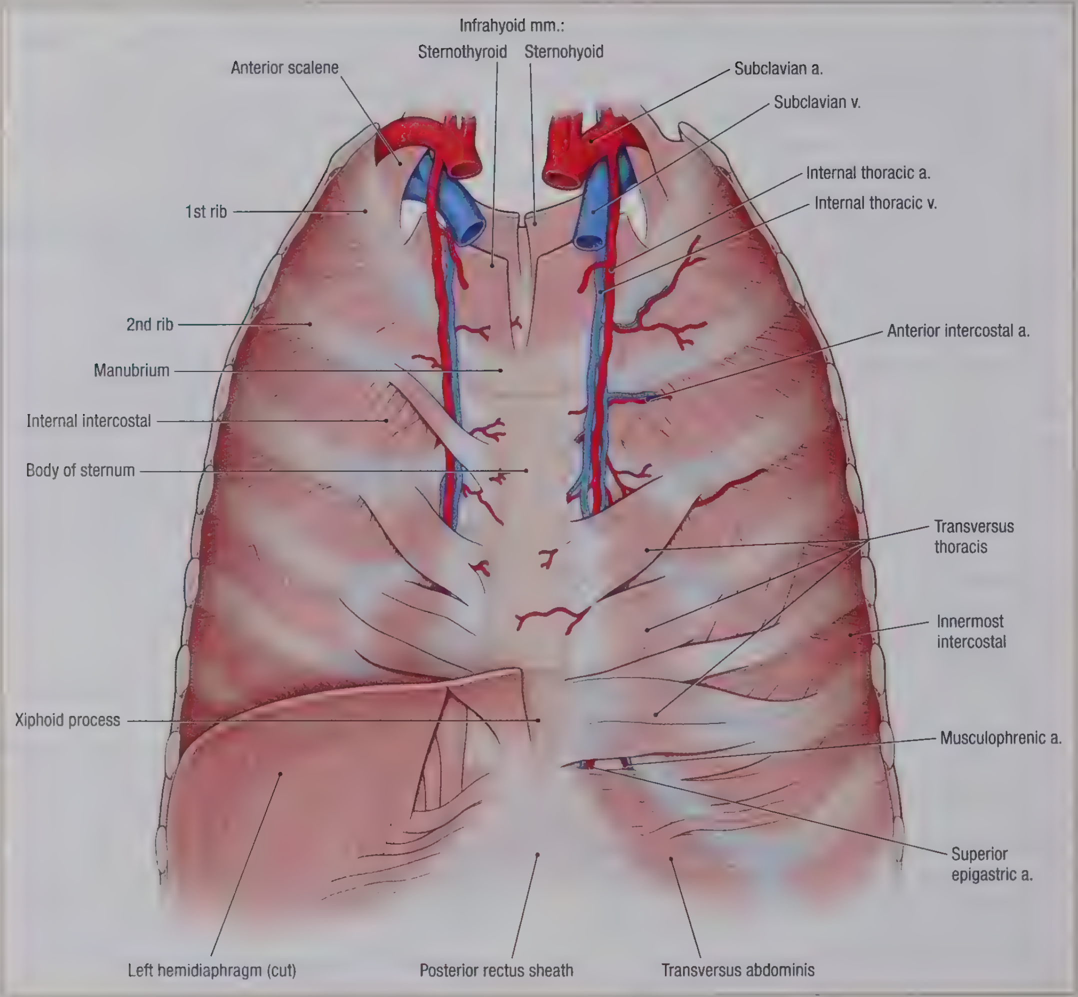

Infrahyoid mm.:
Sternothyroid
Sternohyoid
Anterior scalene
Subclavian a.
Subclavian v.
Internal thoracic a.
Internal thoracic v.
1st rib
2nd rib
Manubrium
Internal intercostal
Body of sternum
Anterior intercostal a.
Transversus thoracis
Innermost intercostal
Xiphoid process
Musculophrenic a.
Superior epigastric a.
Left hemidiaphragm (cut)
Posterior rectus sheath
Transversus abdominis

FIGURE 3.7 ● Anterior thoracic wall. Posterior view.

To reduce the risk of injury, fold the serratus anterior muscle into the thoracic cavity over the cut ends of the ribs before you begin palpating the pleural cavities.

3. Use paper towels or a turkey baster to remove fluid that may have collected in the pleural cavity during the embalming process.
4. Identify the subdivisions of **parietal pleura**, the outer lining of the serous membrane enclosing the pleural cavities, beginning with the **costal pleura** on the inner surface of the thoracic wall. Observe that some of the costal parietal pleura was cut and removed with the anterior thoracic wall.
5. Identify the **mediastinal parietal pleura** lining the mediastinum medially and the **diaphragmatic parietal pleura** covering the superior surface of the diaphragm. *Note that endothoracic fascia underlies all the subdivisions of parietal pleura.*
6. Identify the **cervical pleura (pleural cupula)** extending superior to the first rib.
7. Observe that the parietal pleura is folded sharply at the **lines of pleural reflection**, where the costal pleura meets the diaphragmatic pleura and where the costal pleura meets the mediastinal pleura.
8. The areas where one parietal pleura contacts another parietal pleura are called **pleural recesses**. Identify the two **costodiaphragmatic recesses** (left and right), which are located at the most inferior limits of the parietal pleura.
9. Using the removed portion of the anterior thoracic wall, appreciate the relative location of the two **costomediastinal recesses** (larger on the left than

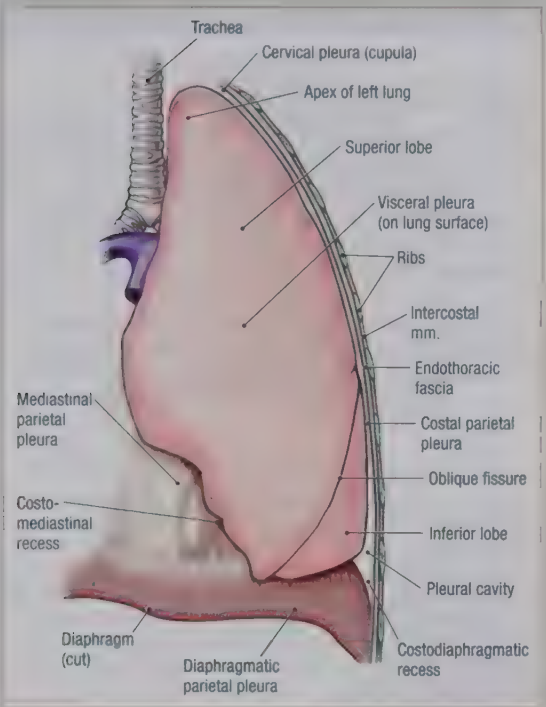


FIGURE 3.8 ● Pleural cavity and pleurae of left lung. Anterior view.

the right), which occur posterior to the sternum where costal pleura meets mediastinal pleura.

10. Inferiorly along the lateral border of the diaphragm, place your fingers in the **costodiaphragmatic recess** and follow it posteriorly observing the acute angle that the diaphragm makes with the inner surface of the thoracic wall. *Note that during quiet inspiration, the inferior border of the lung does not extend into the costodiaphragmatic recess.*
11. Place your hand between the lung and the mediastinum and palpate the **root of the lung**, which comprised the physical structures passing from the mediastinum in and out of the lung. *Note that here, at the root of the lung, the mediastinal pleura is continuous with the visceral pleura and demarcates the boundary of the hilum of the lung.*
12. Palpate the **pulmonary ligament**, which extends inferior to the root of the lung, anchoring the inferior lobe of each lung to the mediastinum.
13. Observe that each lung is completely covered with **visceral pleura (pulmonary pleura)**. Make no attempt to remove the visceral pleura because this will destroy the lung tissue.
14. Observe that the root of the lung is attached to the mediastinum but that all other parts of the lung should slide freely against the parietal pleura as the lung moves within the **pleural cavity**, the space between the visceral pleura and the parietal pleura. *Note that in the living body, the pleural cavity is a potential space, and visceral pleura touches parietal pleura separated only by a thin layer of serous fluid.*
15. Use your fingers to trace the periphery of the lung within the pleural cavity and break any pleural adhesions between visceral and parietal pleurae that may be present because they are the result of disease processes.

CLINICAL CORRELATION

**Pleural Cavity (Pneumothorax, Pleural Effusion, Hemothorax)**

ATLAS 3.27

Under pathologic conditions, the potential space of the pleural cavity may become a real space. With trauma, air may enter the pleural cavity causing the lung to collapse due to the change in intrathoracic pressure and the elasticity of the lung tissue as seen in pneumothorax. Excess fluid may also accumulate in the pleural cavity and compress the lung producing breathing difficulties. The fluid could be excess serous fluid from pleural effusion or blood accumulation resulting in hemothorax.

## Dissection Follow-up

1. Review the attachments and the actions of the pectoralis major and minor, the serratus anterior, and the transversus thoracis muscles.
2. Use the dissected specimen to project the lines of pleural reflection to the anterior thoracic wall.
3. Review the course of the internal thoracic artery from its origin on the subclavian artery to its terminal bifurcation and name its branches.
4. Review the course of the intercostal nerves and understand that they provide somatic innervation (including pain fibers) to the costal pleura.
5. Replace the anterior thoracic wall, the serratus anterior, and pectoralis minor and major muscles in their correct anatomical positions.

# LUNGS

## Dissection Overview

The respiratory system can be subdivided into conducting and respiratory subdivisions. The lungs are the primary respiratory organs in humans and form part of the lower aspect of the conducting portion of the respiratory system. The alveoli, which are the gas exchange portion of the lungs within the respiratory subdivision, are not visible without the aid of a microscope; however, the gross structures of the lungs and the conducting system are readily visible for study.

Although the lungs are bilateral organs, the right and left lungs have distinct anatomical differences that will be studied. Bronchiole arteries and lymphatics enter and exit the medial surface of the lung at the hilum along with the root of the lung consisting of the bronchi, pulmonary artery, and pulmonary veins. The hilum is a gap between the lungs serous parietal and visceral membranes as shown in FIGURE 3.9.

The order of dissection will be as follows: The surface features and relationships of the lungs seen from an anterior view will be studied with the lungs in the thorax. The lungs will then be removed, and the study of surface features and relationships of the lungs will be completed. The hilum and root of the lung will be studied.

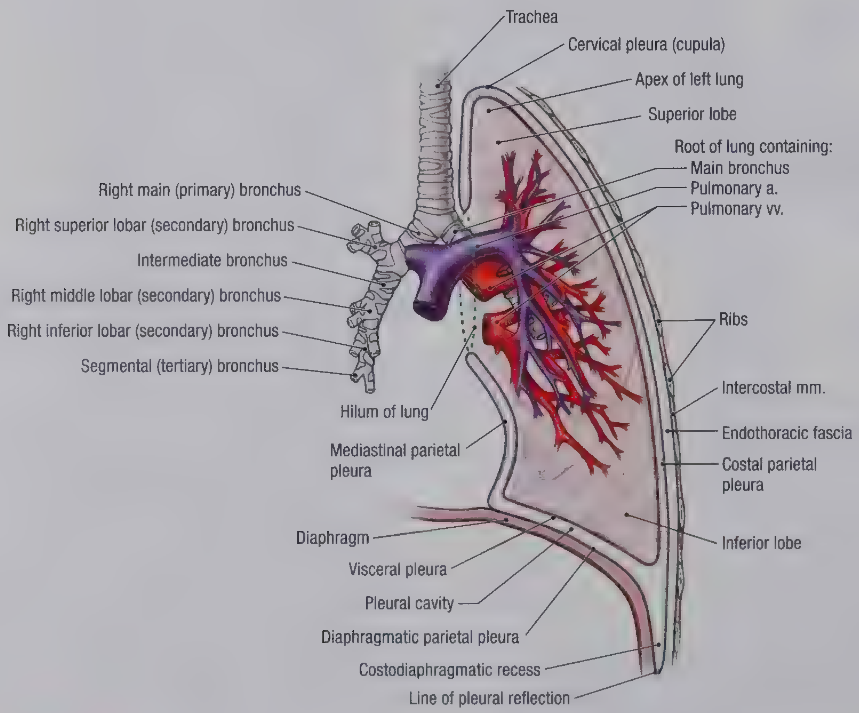

Trachea
Cervical pleura (cupula)
Apex of left lung
Superior lobe
Root of lung containing:
Main bronchus
Pulmonary a.
Pulmonary vv.
Right main (primary) bronchus
Right superior lobar (secondary) bronchus
Intermediate bronchus
Right middle lobar (secondary) bronchus
Right inferior lobar (secondary) bronchus
Segmental (tertiary) bronchus
Ribs
Intercostal mm.
Hilum of lung
Endothoracic fascia
Mediastinal parietal pleura
Costal parietal pleura
Diaphragm
Inferior lobe
Visceral pleura
Pleural cavity
Diaphragmatic parietal pleura
Costodiaphragmatic recess
Line of pleural reflection

FIGURE 3.9 ■ Coronal (frontal) section through left thoracic cavity near midaxillary line. Anterior view.

## Dissection Instructions

### Lungs in the Thorax

ATLAS 3.24, 3.27; VIDEO 3.3.1

1. Refer to FIGURE 3.10.
2. Observe the lungs in situ and identify their three surfaces beginning with the **costal surface**, which, as its name infers, is the surface of the lung adjacent to the ribs.
3. Gently pull a lung laterally and identify the **mediastinal** surface of the lung, which rests in contact with the centrally located mediastinum.
4. Elevate the inferior aspect of the lung and identify the **diaphragmatic** surface of the lung lying directly over the diaphragm. *Note that contraction of diaphragmatic muscle fibers pulls the diaphragm inferiorly, which increases the volume of the thoracic cavity and lungs consequently lowering the pressure in the lungs to draw in air.*

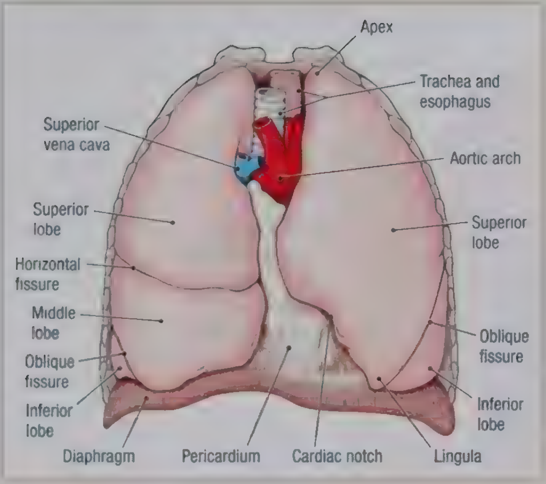


FIGURE 3.10 ■ Thoracic cavity with lungs in situ. Anterior view.

5. Observe that the right lung has three lobes (**superior**, **middle**, and **inferior**), whereas the left lung has two lobes (**superior** and **inferior**). *Note that variations in the number of lobes may occur.*
6. Observe the **oblique fissure (major fissure)** on both lungs just superior to the inferior lobe. Using the anterior thoracic wall as a guide, observe that the oblique fissure lies deep to the fifth rib laterally and deep to the sixth costal cartilage anteriorly.
7. Identify the **horizontal fissure (minor** or **transverse fissure)** on the right lung between the superior and middle lobes.
8. Using the anterior thoracic wall as a guide, observe that the horizontal fissure lies deep to the fourth rib and fourth costal cartilage.
9. Observe that the **apex** of the lung lies superior to the body of the first rib along with the associated cervical pleura and therefore lies superior to the plane of the superior thoracic aperture in the neck.
10. Between the right and left pleural cavities, identify the **pericardium** or **pericardial sac**. The pericardium occupies the midline between the lungs, lies posterior to the sternum and costal cartilages, and contains the heart.
11. Insert your hand into the pleural cavity between the pericardium and the lung and palpate the structures within the **root of the lung**. Each root of the lung consists of the pulmonary vessels and the main or primary bronchus.
12. On the lateral surface of the pericardium, identify the **phrenic nerve** and the **pericardiacophrenic vessels** travelling together deep to the mediastinal pleura.
13. Observe that the phrenic nerve and pericardiacophrenic vessels pass anterior to the root of the lung. Do not dissect the phrenic nerve or pericardiacophrenic vessels at this time because they will be dissected with the mediastinum.

## Removal of the Right Lung

ATLAS 3.30, 3.32; VIDEO 3.3.2

1. Refer to FIGURE 3.10.
2. Retract the right lung laterally to stretch the root of the lung while preserving the phrenic nerve and pericardiacophrenic vessels medially.
3. While retracting the lung, use scissors or a scalpel to carefully transect the root of the lung halfway between the lung and the mediastinum. Take care not to cut into the mediastinum or the lung.
4. Gently pull the lung laterally to determine that the root of the lung is completely transected with a probe ensuring the pulmonary ligament has been cut.
5. Slide your hands completely under the right lung, ensuring you are not within the oblique fissure and lift it from the pleural cavity. Pay particular attention not to cut yourself on the sharp edges of the ribs while doing so. *Note that the lung tissue is quite delicate, and the lungs must be removed gently to avoid damaging the tissue or separating the lobes.*
6. Refer to FIGURE 3.11.
7. Identify the **superior, middle, and inferior lobes** and the **horizontal fissure**.
8. Identify the **costal**, **mediastinal**, and **diaphragmatic surfaces of the right lung**.
9. Identify the **anterior**, **posterior**, and **inferior borders of the right lung**.
10. On the mediastinal surface of the **right lung**, identify the shallow **cardiac impression** anterior to the **esophageal impression**.
11. Identify the **impression of the arch of the azygos vein** arching superior to the root of the lung toward the **superior vena cava impression**.
12. On the medial surface of the right lung, examine the **root of the lung** and identify the **main (primary) bronchus**, **pulmonary artery**, and **pulmonary veins**.
13. Observe that the pulmonary artery is usually superior to the pulmonary veins. *Note that the pulmonary artery contains oxygen-poor blood and the pulmonary veins contain oxygen-rich blood.*
14. Observe that the right main bronchus lies posterior to the pulmonary artery.
15. Insert a probe into the lumen of the right main bronchus and verify its pattern of branching into each lobe. *Note that the right main bronchus may have already divided within the mediastinum.*
16. In the right lung, identify the **superior**, **middle**, and **inferior lobar (secondary) bronchi**. *Note that the right superior lobar bronchus passes superior to the right pulmonary artery and therefore is also called the "eparterial bronchus."*

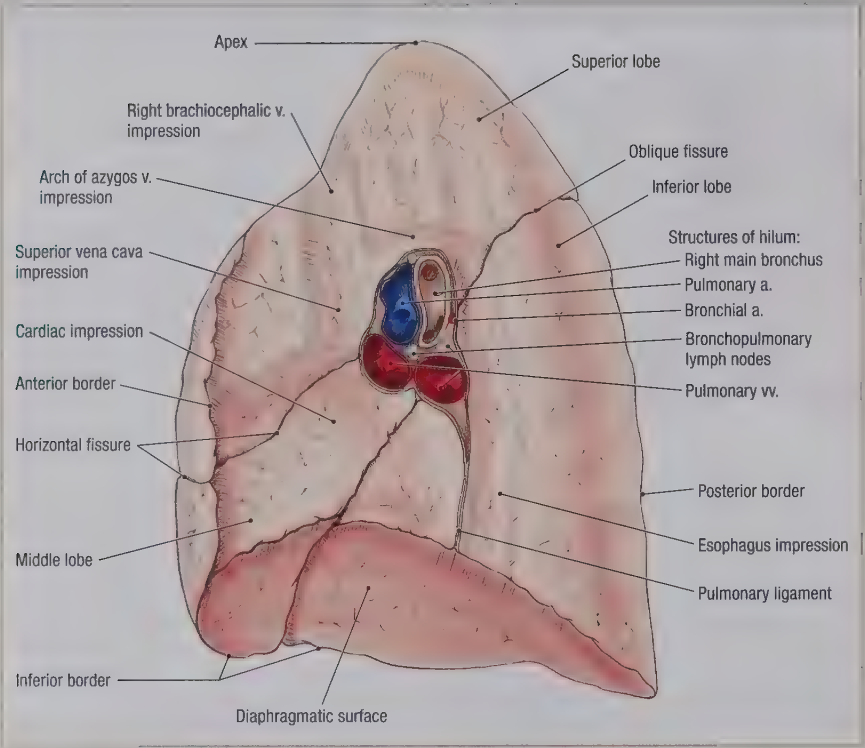

Apex
Superior lobe
Right brachiocephalic v. impression
Oblique fissure
Arch of azygos v. impression
Inferior lobe
Structures of hilum:
Superior vena cava impression
Right main bronchus
Pulmonary a.
Bronchial a.
Cardiac impression
Bronchopulmonary lymph nodes
Anterior border
Pulmonary vv.
Horizontal fissure
Posterior border
Middle lobe
Esophagus impression
Pulmonary ligament
Inferior border
Diaphragmatic surface

FIGURE 3.11 ● Mediastinal surface of right lung. Medial view.

## Removal of the Left Lung

ATLAS 3.31, 3.33; VIDEO 3.3.3

1. Observe that the heart is positioned more to the left-hand side of the thoracic cavity, and the thoracic aorta descends on the left, which combine to often make the left lung more difficult to remove despite its smaller size.
2. Repeat steps 1 to 4 from the **Removal of the Right Lung** instructions, ensuring that you are not grasping only the superior lobe of the left lung and are posterior to the entire lung. Pay particular attention not to cut yourself on the sharp edges of the ribs while doing so.
3. Refer to FIGURE 3.12.
4. Identify the **costal**, **mediastinal**, and **diaphragmatic surfaces of the left lung**.
5. Identify the **anterior**, **posterior**, and **inferior borders of the left lung**.
6. On the mediastinal surface of the **left lung**, identify the more prominent **cardiac impression** inferior to the **aortic arch impression** and anterior to the **thoracic aorta impression**.
7. Identify the **cardiac notch** on the anterior border of the superior lobe and verify that in the anatomical position, it is positioned anterior to the heart.
8. Identify the **lingula**, the inferior, medial portion of the superior lobe, and verify that it is the homolog of the middle lobe of the right lung.
9. Examine the **root of the lung** and identify the **main (primary) bronchus, pulmonary artery,** and **pulmonary veins**.
10. Observe that the pulmonary artery is usually superior to the pulmonary veins. *Note that the pulmonary artery contains oxygen-poor blood and the pulmonary veins contain oxygen-rich blood.*
11. Observe on the left lung that the left main bronchus contains cartilage and commonly lies inferior to the pulmonary artery.
12. Insert a probe into the lumen of the left main bronchus and verify its pattern of branching into each lobe. *Note that the left main bronchus may have already divided within the mediastinum.*
13. Identify the **superior** and **inferior lobar (secondary) bronchi**.
14. Compare the two lungs and observe that the right lung is shorter but has greater volume than the left lung.
15. Verify that each lung has a **superior** and **inferior lobe** separated by the **oblique fissure** and observe that most of the inferior lobe lies posteriorly and that most of the superior lobe lies anteriorly in the thorax.

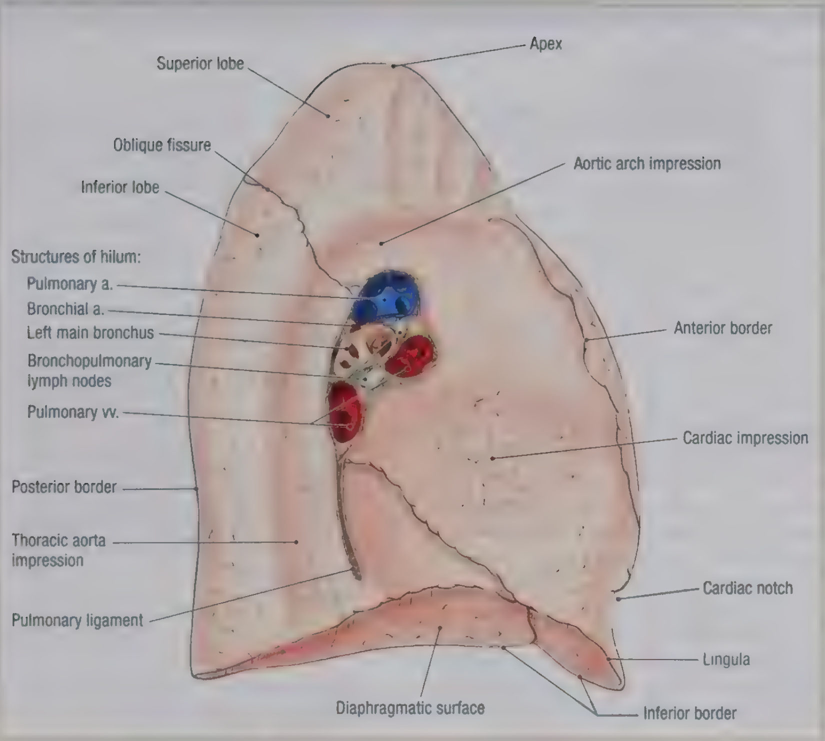

Apex
Superior lobe
Oblique fissure
Aortic arch impression
Inferior lobe
Structures of hilum:
Pulmonary a.
Bronchial a.
Left main bronchus
Bronchopulmonary lymph nodes
Pulmonary vv.
Anterior border
Cardiac impression
Posterior border
Thoracic aorta impression
Cardiac notch
Pulmonary ligament
Lingula
Diaphragmatic surface
Inferior border

FIGURE 3.12 ■ Mediastinal surface of left lung. Medial view.

16. Use blunt dissection to follow one lobar bronchus approximately 3 to 4 cm deeper into the lung tissue until it branches into several **segmental (tertiary) bronchi**. *Note that the right lung contains 10 segmental bronchi and the left lung contains either 9 or 10, each of which supply one* ***bronchopulmonary segment*** *of the lung.*
17. Identify a **bronchial artery** coursing along the surface of the main or lobar bronchi.
18. In addition to the already identified structures, at the hilum of the lung briefly look for bronchial veins, lymph nodes, lymph vessels, and autonomic nerves. *Note that the lungs have a rich nerve supply via the anterior and posterior pulmonary plexuses with sympathetic contributions from the right and left sympathetic trunks and parasympathetic contributions from the right and left vagus nerves.*

## Dissection Follow-up

1. Review the surfaces, borders, and component parts of each lung.
2. Review the structures of the root of the lung and the respective location of the bronchus and pulmonary artery for the right and left lungs.
3. Review the regional naming pattern of the parietal pleura and review the relationship of the pleural reflections to the thoracic wall, the diaphragm, and mediastinum to create the costomediastinal and costodiaphragmatic recesses.
4. Review the regional parts of the parietal pleura and the locations of reflection to create spaces within the pleural cavities.
5. Review the relationship of the phrenic and vagus nerves to the root of the lung and the pericardium on the right and left sides of the mediastinum.
6. Replace the lungs in their correct anatomical positions within the pleural cavities or place them in a container following your labs protocol for removed organs.
7. Replace the anterior thoracic wall and project the borders, surfaces, and fissures of the lungs to the surface of the thoracic wall.

# MEDIASTINUM

## Dissection Overview

The mediastinum is the region between the two pleural cavities. For descriptive purposes, the mediastinum can be divided into four parts based on their relative locations as shown in FIGURE 3.13. An imaginary transverse plane at the level of the sternal angle intersects the T4/T5 IV disc and separates the superior mediastinum from the inferior mediastinum. The inferior mediastinum is further subdivided by the pericardium into three parts. The anterior mediastinum lies between the sternum and the pericardium and, in children and adolescents, contains part of the thymus. The middle mediastinum is centrally located and contains the pericardium, the heart, and the roots of the great vessels. The posterior mediastinum lies posterior to the pericardium and anterior to the bodies of vertebrae T5–T12 and contains structures that pass between the neck, thorax, and abdomen (esophagus, vagus nerves, azygos system of veins, thoracic duct, and thoracic aorta). It is worth noting that some structures that course through the mediastinum (esophagus, vagus nerve, phrenic nerve, and thoracic duct) pass through more than one mediastinal subdivision.

The order of dissection will be as follows: The mediastinal pleura will be examined, and mediastinal structures will be palpated. The costal and mediastinal pleurae will then be removed. The pericardium will be opened, and its relationship to the heart and great vessels will be explored. The characteristics of the parietal serous pericardium will then be studied. The heart will be removed by cutting the great vessels.

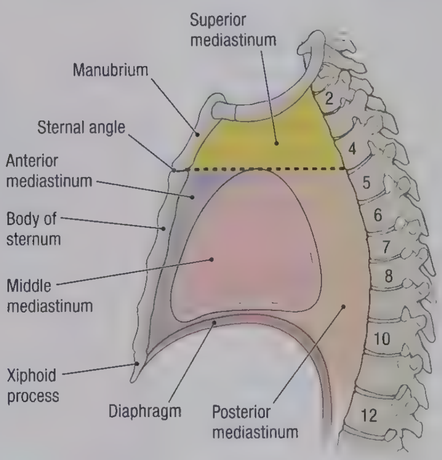


FIGURE 3.13 ● Boundaries and subdivisions of the mediastinum. Lateral view.

## Dissection Instructions

### Inferior Mediastinum

ATLAS 3.28, 3.73, 3.74; VIDEO 3.4.1

1. Refer to FIGURE 3.13.
2. Observe that the **mediastinum** has a **superior boundary** of the superior thoracic aperture, an **inferior boundary** of the diaphragm, an **anterior boundary** of the sternum, a **posterior boundary** of vertebral bodies T1–T12, and **lateral boundaries** of mediastinal pleurae (left and right).
3. Use the anterior thoracic wall to identify the location of the sternal angle relative to the mediastinum. Verify that the sternal angle is at the same height as the T4/T5 IV disc, and that a plane intersecting these points would subvide the mediastinum into superior and inferior portions.
4. Palpate the **mediastinal pleura** and observe that the plane of the sternal angle is at the level of the **superior border of the pericardium**, the **bifurcation of the trachea**, the **end of the ascending** aorta, the **beginning** *and* **end of the arch of the aorta**, and the **beginning of the thoracic aorta**.
5. Observe that as you move from anterior to posterior, the mediastinal pleura is in contact with the **pericardium** and **root of the lung** and either the **esophagus** on the right side or the **thoracic aorta** on the left side.
6. Follow the mediastinal pleura further posteriorly until it contacts the sides of the vertebral bodies where it transitions to **costal pleura**.
7. Detach the costal pleura in the midaxillary line near the cut ends of ribs 1 to 5 and peel the costal pleura off the inner surface of the posterior thoracic wall, moving from lateral to medial. Observe that the **endothoracic fascia** provides a natural cleavage plane for separation of costal pleura from the thoracic wall.
8. Remove the costal pleura up to the point where it covers the vertebral column.
9. Identify the left and right **phrenic nerves** and the left and right **pericardiacophrenic vessels** coursing deep to the mediastinal pleura. Observe that the phrenic nerve and pericardiacophrenic vessels are located between the mediastinal pleura and the pericardium about 1.5 cm anterior to the root of the lung.
10. Clean and follow the phrenic nerve and pericardiacophrenic vessels inferiorly toward the diaphragm. Recall that the phrenic nerves arise from vertebral levels C3–C5 and that each phrenic nerve is the only motor innervation to the ipsilateral half of the diaphragm as well as sensory innervation to the mediastinal and diaphragmatic parietal pleurae.

## Heart in the Mediastinum

ATLAS 3.24, 3.44; VIDEO 3.4.2

1. Refer to FIGURE 3.14.
2. Identify the **pericardial sac (pericardium)** that encloses the heart and observe that it is pierced by the **aorta**, the **pulmonary trunk**, and the **superior vena cava** superiorly; the **four pulmonary veins** posterolaterally; and the **inferior vena cava** inferiorly.
3. Observe that the pericardial sac lies deep to the **mediastinal parietal pleura**. The pericardial sac consists of two layers: the **fibrous pericardium** externally and the smooth **serous pericardium** lining the inner surface.
4. Remove the mediastinal parietal pleura and associated fat covering the anterior surface of the pericardial sac between the right and left phrenic nerves and pericardiacophrenic vessels.
5. Observe that the pericardial sac is attached to the **central tendon of the diaphragm** and thus will move up and down with the diaphragm during inspiration and expiration carrying the heart with it.
6. Use forceps to elevate the anterior surface of the pericardium and use scissors to make a vertical cut through the pericardium from just above the diaphragm toward the ascending aorta (**Cut 1**).
7. Make a transverse cut around the periphery of the pericardium superiorly just below the point of reflection of the pericardium with the great vessels (**Cut 2**). Take care to not cut the phrenic nerves and accompanying vessels.
8. Make a transverse cut around the periphery of the pericardium inferiorly just above the point of reflection of the pericardium with the diaphragm (**Cut 3**).

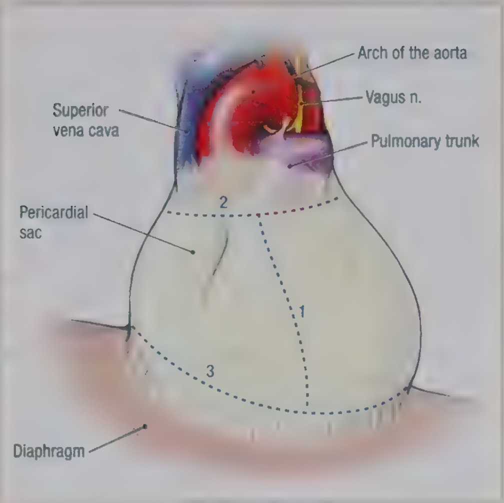

Arch of the aorta
Vagus n.
Superior vena cava
Pulmonary trunk
2
Pericardial sac
1
3
Diaphragm

FIGURE 3.14 ■ Opening the pericardial sac. Anterior view.

9. Open the flaps of pericardium widely.
10. Refer to FIGURE 3.15.
11. On the inner surface of the pericardial sac, identify the smooth surface of the **parietal layer of serous pericardium**.
12. Observe that the parietal layer of serous pericardium reflects onto the heart as the **visceral layer of serous pericardium (epicardium)** at the roots of the great vessels.

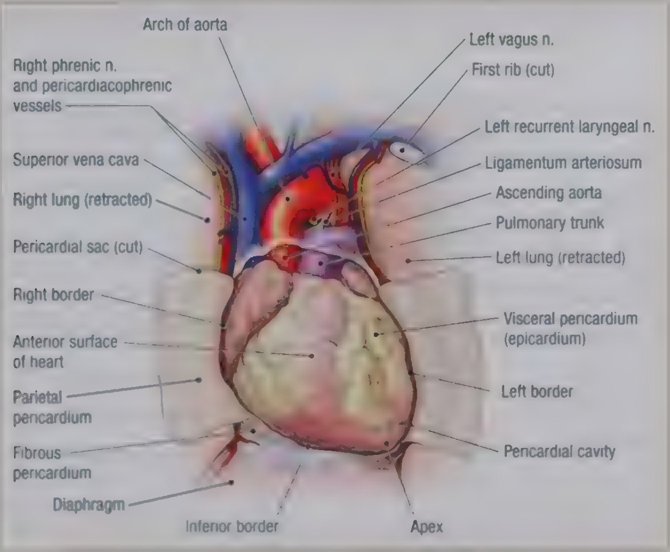

Arch of aorta
Right phrenic n. and pericardiacophrenic vessels
Superior vena cava
Right lung (retracted)
Pericardial sac (cut)
Right border
Anterior surface of heart
Parietal pericardium
Fibrous pericardium
Diaphragm
Inferior border
Apex
Left vagus n.
First rib (cut)
Left recurrent laryngeal n.
Ligamentum arteriosum
Ascending aorta
Pulmonary trunk
Left lung (retracted)
Visceral pericardium (epicardium)
Left border
Pericardial cavity

FIGURE 3.15 ■ Heart in situ with reflected pericardial sac. Anterior view.

13. Use your fingers to palpate and observe the now-visible **pericardial cavity**, a potential space between the parietal and visceral layers of the serous pericardium. Normally, the pericardial cavity contains only a thin film of serous fluid that lubricates the serous surfaces and allows free movement of the heart within the pericardium.
14. Within the pericardial cavity, identify the **superior vena cava**, **ascending aorta**, **pulmonary trunk**, **pulmonary veins**, and the **inferior vena cava**.
15. Examine the surface of the heart and observe that the **right border of the heart** is formed by the **right atrium**.
16. Observe that the majority of the anterior surface of the heart and the **inferior border** are formed by the **right ventricle** and a small part of the **left ventricle** and that the **left border** is formed by the left ventricle.
17. The **superior border of the heart** is formed by the **right** and **left atria** and **auricles**. *Note that the right, inferior, and left borders of the heart are easily seen on a chest radiograph. The superior heart border is not easily seen on a chest radiograph.*
18. Identify the **apex of the heart** on the inferior left side of the heart and observe that it is part of the left ventricle. *Note that the apex of the heart is normally located deep to the left fifth intercostal space, approximately 9 cm lateral to the midline.*
19. Identify the **base of the heart** formed by the left atrium and part of the right atrium. Clinicians often refer to the emergence of the great vessels from the heart as its base.
20. Place the anterior thoracic wall into its correct anatomical position, and use the cadaver to project the outline of the heart to the surface of the thoracic wall.

**CLINICAL CORRELATION**

**Pericardium (Pericardial Effusion, Hemopericardium, Cardiac Tamponade)**

ATLAS 3.28

Inflammatory diseases can cause fluid to accumulate in the pericardial cavity (pericardial effusion). Bleeding into the pericardial cavity (hemopericardium) may result from penetrating heart wounds or from perforation of weakened heart muscle following myocardial infarction (MI). As the pericardium is composed of fibrous connective tissue, it cannot stretch, thus fluids that collect in the pericardial cavity will compress the heart (cardiac tamponade).

## Removal of the Heart

ATLAS 3.45, 3.46, VIDEO 3.4.3

1. Refer to FIGURE 3.16.
2. External to the pericardium, identify the **arch of the aorta**.
3. Use blunt dissection to identify and clean the **left vagus nerve** where it crosses the left side of the aortic arch.
4. Observe that the **vagus nerve** descends within the thorax posterior to the root of the lung, whereas the phrenic nerve passes anterior to the root of the lung.
5. Identify the initial portion of the **left recurrent laryngeal nerve** where it branches from the left vagus nerve inferior to the aortic arch and posterior to the ligamentum arteriosum.

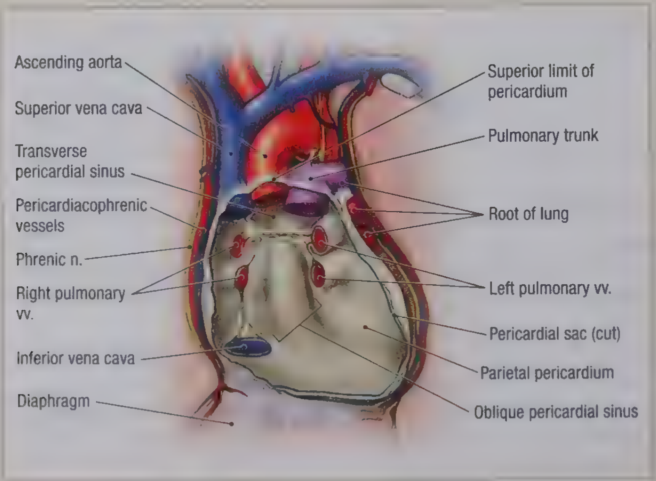


FIGURE 3.16 ■ Pericardial cavity and sinuses with heart removed. Anterior view.

6. Use your fingers to gently open the interval between the concavity of the aortic arch and pulmonary trunk and identify the **ligamentum arteriosum**, connecting the left pulmonary artery to the inferior aspect of the arch of the aorta.
7. Place your right hand in the pericardial cavity with your fingers posterior to the heart in the **oblique pericardial sinus**. Lift the heart gently while pushing your fingers superiorly until they are stopped by the reflection of serous pericardium.
8. Push your right index finger posterior to the pulmonary trunk and ascending aorta, proceeding from left to right, until your fingertip emerges between the superior vena cava and the ascending aorta in the **transverse pericardial sinus**.
9. Use your fingers to explore the lines of reflection of the serous pericardium where the great vessels (aorta, pulmonary trunk, superior vena cava, inferior vena cava, and four pulmonary veins) enter and exit the heart.
10. Place a probe through the transverse pericardial sinus.
11. Cut the **ascending aorta** and the **pulmonary trunk** anterior to the probe about 1.5 cm superior to the point where the aorta and pulmonary trunk emerge from the heart.
12. Cut the **superior vena cava** about 1 cm superior to its junction with the right atrium.
13. Lift the apex of the heart superiorly and cut the **inferior vena cava** close to the surface of the diaphragm.
14. Continue lifting the apex of the heart and cut the **four pulmonary veins** very close to the inner surface of the pericardial sac where they form the lateral boundaries of the oblique pericardial sinus.
15. Cut the remaining reflections of the serous pericardium from its posterior surface to the inner surface of the pericardial sac and remove the heart from the pericardial sac.
16. Examine the posterior aspect of the pericardium and identify the openings of eight vessels and the lines of the pericardial reflections.

## Dissection Follow-up

1. Review the parts of the mediastinum and state their boundaries.
2. Review the attachments of the pericardium to the diaphragm and to the roots of the great vessels.
3. Compare the appearance and functional properties of the parietal and visceral serous pericardia to those of the parietal and visceral pleurae.
4. Return the reflected tissue back to anatomical position.
5. Review the embryonic origin of the transverse and oblique pericardial sinuses.

# EXTERNAL FEATURES OF THE HEART

## Dissection Overview

The heart is a vital organ responsible for circulating blood throughout the human body by contraction of its muscular wall. As the heart contracts, it effectively functions as a two-pump system with one side devoted to circulating oxygen-poor blood, and the other circulating oxygen-rich blood. As the blood circulates, it collects within four different chambers separated from one another by septa and valves.

Dissection of the heart will proceed in two stages: The external features of the heart will be studied, including its vascular supply. The internal features of each chamber of the heart will then be studied.

The order of dissection will be as follows: The surface features of the heart will be examined from both an anterior and superior perspective. The valves and cusps of the aortic and pulmonary semilunar valves will be studied. The coronary veins will be cleaned and isolated. The coronary arteries will be cleaned and isolated.

# Dissection Instructions

## Surface Features and Valves of the Removed Heart

ATLAS 3.43, 3.46A, 3.58; VIDEO 3.5.1

1. Refer to FIGURE 3.17.
2. Examine the external surface of the heart and identify the **coronary (atrioventricular) sulcus** coursing around the circumference of the heart, separating the atria from the ventricles.
3. Identify the **anterior interventricular sulcus** separating the right and left ventricles on the **sternocostal (anterior) surface** of the heart and observe that the right ventricle predominantly forms the anterior surface of the heart. *Note that the interventricular sulci indicate the location of the interventricular septum internally, which lies at a right angle to the coronary sulcus.*
4. On the anterior surface of the heart, identify the **right auricle** extending from the right atrium, and the **left auricle** extending from the left atrium.
5. Observe that left ventricle predominantly forms the **diaphragmatic (inferior) surface** of the heart.
6. On the inferior surface of the heart, identify the **opening of the inferior vena cava** and the **posterior interventricular sulcus** running from the apex of the heart to the coronary sulcus. *Note that the cardiac veins and coronary arteries are located in the coronary and interventricular sulci.*
7. Observe that the **left pulmonary surface** of the heart is formed mainly by the left ventricle and is aligned with the cardiac impression of the left lung.
8. Observe that the **right pulmonary surface** of the heart is formed mainly by the right atrium.
9. Insert a probe into the lumen of the ascending aorta and gently open the aortic valve to view the connection of the aorta to the left ventricle through the aortic valve.
10. Identify the **right cusp of the aortic valve** and the **opening of the right coronary artery** and observe that it lies somewhat anteriorly due to the rotation of the vessels during embryonic development.
11. Identify the **left cusp of the aortic valve** and the **opening of the left coronary artery** and observe that it lies somewhat posteriorly.
12. Identify the **posterior cusp of the aortic valve**, often called the noncoronary cusp because no coronary artery arises in this location, and observe that it lies toward the right border of the heart.
13. Observe that behind each valve cusp is a small pocket called an **aortic sinus** (**right**, **left**, and **posterior**, respectively).

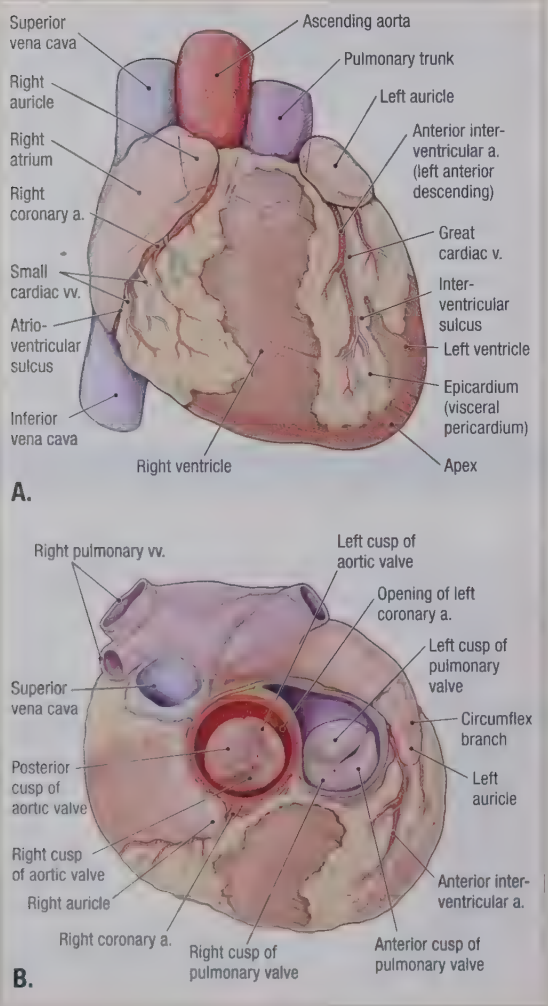

Superior vena cava
Ascending aorta
Pulmonary trunk
Right auricle
Left auricle
Right atrium
Anterior interventricular a. (left anterior descending)
Right coronary a.
Great cardiac v.
Small cardiac vv.
Interventricular sulcus
Atrioventricular sulcus
Left ventricle
Epicardium (visceral pericardium)
Inferior vena cava
Right ventricle
Apex
A.
Right pulmonary vv.
Left cusp of aortic valve
Opening of left coronary a.
Left cusp of pulmonary valve
Superior vena cava
Circumflex branch
Posterior cusp of aortic valve
Left auricle
Right cusp of aortic valve
Anterior interventricular a.
Right auricle
Right coronary a.
Right cusp of pulmonary valve
Anterior cusp of pulmonary valve
B.

FIGURE 3.17 ● Surface anatomy of the heart. **A.** Anterior view. **B.** Superior view.

**CLINICAL CORRELATION**

### Myocardial Infarction (MI)

ATLAS 3.46

Restricted blood flow to the heart tissue leading to necrosis may occur rapidly, as seen in occlusion of a vessel by an embolus (blood clot), or gradually over time as seen in atherosclerosis resulting in ischemia. Once the tissue has become necrotic and nonfunctioning, it is classified as having undergone a MI, often simply referred to as a "heart attack." The most common procedures to restore blood flow to the affected area are the insertion of stents (tubes placed within the occluded coronary vessel), or coronary bypass grafts (the attachment of a "new vessel", often a vein, to both a point before and after the blockage to literally "bypass" the point of blockage). A bypass may be done on a single vessel or on multiple vessels as needed to return blood flow to the heart.

14. Place a probe within the lumen of the pulmonary trunk and gently open the pulmonary valve to view the connection of the pulmonary trunk to the right ventricle.
15. Identify the **right cusp of the pulmonary valve** and observe that it lies somewhat anteriorly in line with the right cusp of the aortic valve.
16. Identify the **left cusp of the pulmonary valve** and observe that it lies somewhat posteriorly in line with the left cusp of the aortic valve.
17. Identify the **anterior cusp of the pulmonary valve** and observe that it lies toward the left border of the heart.
18. Identify the **superior vena cava** on the right side of the heart and observe that it is vertically aligned with the inferior vena cava on the inferior aspect of the right atrium.
19. Identify the openings of the **four pulmonary veins**, two on the right and two on the left, on the posterior surface of the heart draining into the left atrium.

## Cardiac Veins

ATLAS 3.49; VIDEO 3.5.2

***Dissection Note:*** As you study the vessels of the heart, realize that they (and the fat that surrounds them) are located between the visceral pericardium (epicardium) and the muscular wall of the heart. Because the cardiac veins course superficial to the coronary arteries, they will be dissected first.

1. Refer to FIGURE 3.18.
2. Identify the **coronary sinus** on the diaphragmatic surface of the heart. Observe that the coronary sinus is a dilated portion of the venous system of the heart located in the coronary sulcus.
3. Use blunt dissection to clean the fat and portions of the epicardium overlying the coronary sinus. *Note that the coronary sinus is about 2 to 2.5 cm in length and opens into the right atrium. The opening of the coronary sinus will be seen when the internal features of the right atrium are dissected.*
4. Define the borders and surface of the coronary sinus and follow its path around the heart in the coronary sulcus to the point where it receives the **great cardiac vein**.
5. Follow and clean the great cardiac vein onto the sternocostal surface of the heart. Observe that the great cardiac vein often passes deep to the arteries on the anterior aspect of the heart.
6. Clean the great cardiac vein sufficiently to verify its course from the apex of the heart toward the coronary sinus in the anterior interventricular sulcus. *Note that additional veins assist in draining the left ventricle back to the great cardiac vein or coronary sinus.*
7. In the posterior interventricular sulcus, identify and clean the **middle cardiac vein** and trace it to the coronary sinus.
8. Near the location of inferior vena cava, toward the termination of the coronary sinus, identify the **small cardiac vein** coursing laterally around the heart from the right.
9. Use a probe to dissect the small cardiac vein and follow it to the anterior surface of the heart where it courses along the inferior border of the heart.
10. On the anterior surface of the heart, identify the **anterior cardiac veins**, which bridge the atrioventricular sulcus between the right atrium and the right ventricle, and pass superficial to the right coronary artery.
11. Observe that most veins of the heart are tributaries to the coronary sinus, with the exception of the anterior cardiac veins, which drain the anterior wall of the right ventricle directly into the right atrium.

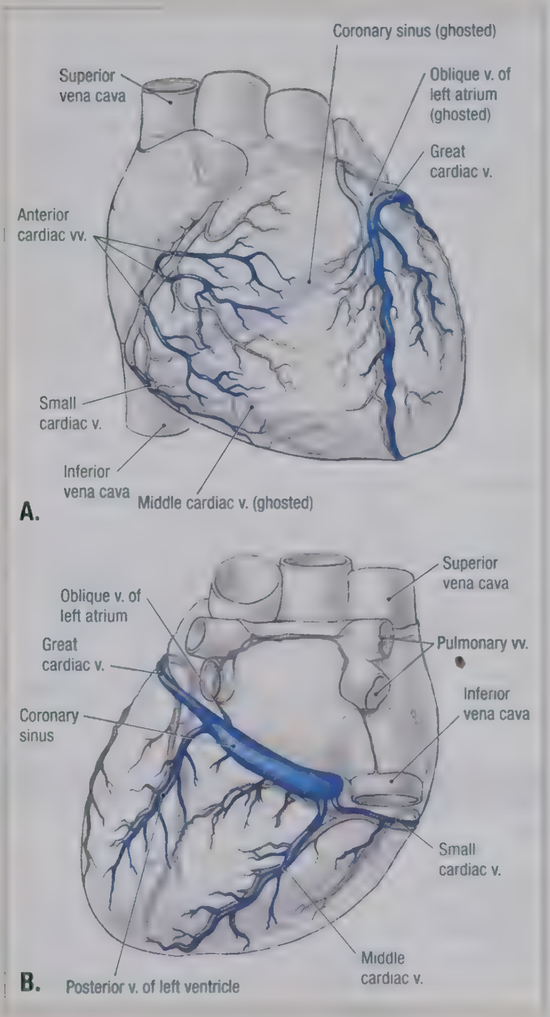


FIGURE 3.18 ● Cardiac veins and coronary sinus. **A.** Anterior view. **B.** Posterior view.

## Coronary Arteries

ATLAS 3.48, 3.50; VIDEO 3.5.3

1. Refer to FIGURE 3.19.
2. Place a probe within the lumen of the aorta into the left aortic sinus and identify the **opening of the left coronary artery** by inserting the tip of the probe into the opening.
3. On the surface of the heart, palpate the tip of the probe inside the left coronary artery between the left auricle and the pulmonary trunk.
4. Use blunt dissection to clean the left coronary artery beginning at the ascending aorta for a short distance inferior to the left auricle. Observe that the left coronary artery is quite short and that it divides into the **anterior interventricular branch** and the **circumflex branch** within the coronary sulcus.
5. Use blunt dissection to clean and follow the path of the **anterior interventricular branch** in the anterior interventricular sulcus toward the apex of the heart. Do not disrupt the great cardiac vein. *Note that clinicians call the anterior interventricular branch of the left coronary artery the left anterior descending (LAD) artery.*
6. Use blunt dissection to clean and follow the **circumflex branch of the left coronary artery** in the coronary sulcus around the left side of the heart.
7. Observe that the circumflex branch of the left coronary artery accompanies the coronary sinus in the coronary sulcus and has several unnamed branches that supply the posterior wall of the left ventricle.
8. Place a probe within the lumen of the aorta into the right aortic sinus and identify the **opening of the right coronary artery** by inserting the tip of the probe into the opening.
9. On the surface of the heart, palpate the tip of the probe inside the right coronary artery in the coronary sulcus between the right auricle and the ascending aorta.
10. Elevate the right auricle and use blunt dissection to clean the right coronary artery.
11. Identify the **anterior right atrial branch**, which arises close to the origin of the right coronary artery and ascends along the anterior wall of the right atrium toward the superior vena cava.
12. Follow and clean the anterior right atrial branch as well as its **sinuatrial (SA) nodal branch**, which supplies the sinuatrial node. *Note that the right atrial and SA nodal branches may be quite small and difficult to find.*
13. Follow the right coronary artery in the coronary sulcus and, if possible, preserve the anterior cardiac veins arching over the artery toward the right atrium.
14. Identify and clean the **right marginal branch** of the right coronary artery, which usually arises near the inferior border of the heart where it accompanies the small cardiac vein.
15. Continue to follow and clean the right coronary artery in the coronary sulcus onto the diaphragmatic surface of the heart. Follow the right coronary artery until it reaches the posterior interventricular sulcus and gives rise to the **posterior interventricular branch**, which accompanies the middle cardiac vein.
16. Follow and clean the posterior interventricular branch toward the apex of the heart where it anastomoses with the anterior interventricular branch of the left coronary artery.

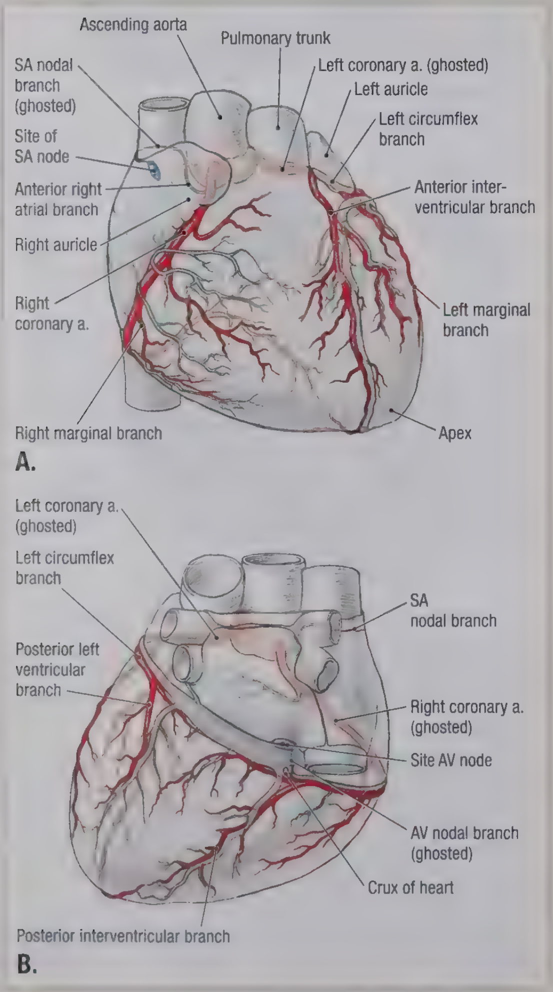

Ascending aorta
Pulmonary trunk
SA nodal branch (ghosted)
Left coronary a. (ghosted)
Left auricle
Site of SA node
Left circumflex branch
Anterior right atrial branch
Anterior inter-ventricular branch
Right auricle
Right coronary a.
Left marginal branch
Right marginal branch
Apex
A.
Left coronary a. (ghosted)
Left circumflex branch
SA nodal branch
Posterior left ventricular branch
Right coronary a. (ghosted)
Site AV node
AV nodal branch (ghosted)
Crux of heart
Posterior interventricular branch
B.

FIGURE 3.19 ■ Right and left coronary arteries and branches. **A.** Anterior view. **B.** Posterior view.

**CLINICAL CORRELATION**

**Coronary Arteries (Heart Dominance)**

ATLAS 3.50, 3.51

In the majority of hearts, the right coronary artery gives rise to the posterior interventricular branch and supplies the left ventricular wall and posterior portion of the interventricular septum, commonly referred to as right dominance. Occasionally, the left coronary artery gives rise to the posterior interventricular branch, a condition referred to as left dominance. Other variations in the branching pattern of the coronary vessels may also occur.

17. Identify the **crux of the heart**, the point where the posterior interventricular sulcus meets the coronary sulcus, and observe that the **artery to the atrioventricular node** arises from the right coronary artery near this location.
18. Remove the remaining fat and visceral pericardium from the surface of the heart to better visualize the heart vasculature.

## Dissection Follow-up

1. Review the borders and surfaces of the heart.
2. On the surface of the heart, review the boundaries and locations of the four chambers.
3. Review the location of the coronary sulcus and interventricular sulci of the heart and name the vessels that course within them.
4. Trace the path of blood from the right aortic sinus to the coronary sinus, naming all vessels that are involved.
5. Trace the path of blood from the left aortic sinus to the apex of the heart and follow the venous return to the coronary sinus, naming all vessels that are involved.
6. Return the heart to the pericardial cavity and position all reflected tissue back to anatomical position.

# INTERNAL FEATURES OF THE HEART

## Dissection Overview

Cardiac muscle tissue within the walls of the heart is regulated by the conducting system of the heart. The "pacemaker" of the heart is the sinuatrial (SA) node located within the wall of the right atrium near the superior end of the crista terminalis near the superior vena cava. Impulses from the SA node pass through the wall of the right atrium to the atrioventricular (AV) node, which then pass in the atrioventricular bundle through the membranous part of the interventricular septum. Subsequently, the atrioventricular bundle divides into right and left bundles, which lie within the muscular part of the interventricular septum and stimulate the ventricles to contract via Purkinje fibers.

Corresponding to the relaxation and contraction of the chambers of the heart, blood passes through the heart from the right atrium to the right ventricle to reach the lungs, and then returns to the heart via the left atrium to then pass to the left ventricle to pump to the heart itself and the remainder of the body. The cuts that will be performed to investigate the chambers of the heart are designed to preserve most of the vessels that have previously been dissected on the surface of the heart.

The order of dissection will be as follows: The right atrium will be opened, and the internal features examined. The right ventricle will be opened, and the internal features examined. The left atrium will be opened, and the internal features examined. The left ventricle will be opened, and the internal features examined.

## Dissection Instructions

***Dissection Note:*** Remove the heart from the dissection field to perform the following dissection sequence leaving the remainder of the thorax covered to prevent desiccation of the tissue. The chambers of the heart will contain clotted blood that must be removed in order to study their internal features more clearly. The clots will be hard and may need to be broken before they can be extracted. Observe the lab rules and regulations for discarding the clotted blood in the proper tissue containers.

### Right Atrium

ATLAS 3.43A, 3.54; VIDEO 3.6.1

1. Refer to FIGURE 3.20.
2. Gently elevate the right auricle with a pair of forceps and use scissors to make a cut through the free edge of the right auricle near its superior border. Insert one blade of the scissors through the opening and make a short horizontal cut toward the right, below the junction of the superior vena cava and the right atrium (**Cut 1**).
3. At the right extent of the horizontal incision through the right atrium (**Cut 1**), make a vertical incision down through the lateral edge of the right atrium, stopping superior to the junction with the inferior vena cava (**Cut 2**).
4. At the inferior extent of the vertical incision through the right atrium (**Cut 2**), make a short horizontal cut toward the left, stopping just short of the coronary sulcus (**Cut 3**).
5. Refer to FIGURE 3.21.

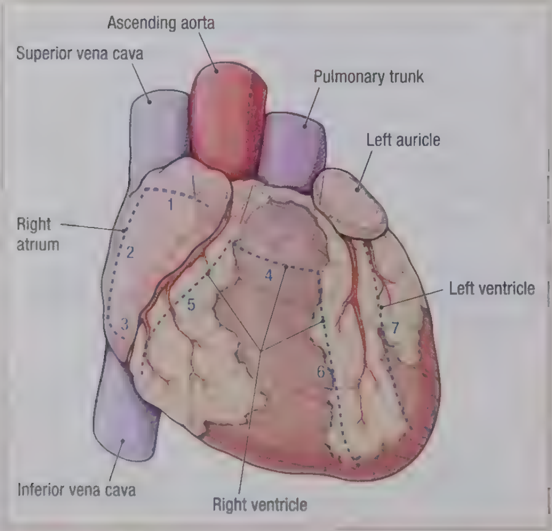

Ascending aorta
Superior vena cava
Pulmonary trunk
Left auricle
Right atrium
1
2
3
4
5
6
7
Left ventricle
Inferior vena cava
Right ventricle

FIGURE 3.20 ■ Opening the chambers of the heart. Anterior view.

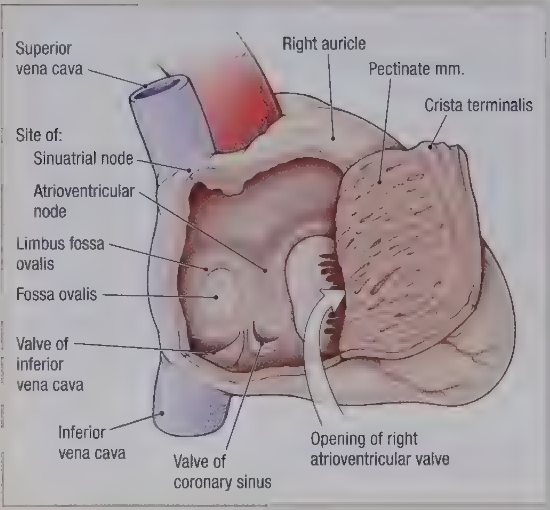

Superior vena cava
Right auricle
Pectinate mm.
Crista terminalis
Site of:
Sinuatrial node
Atrioventricular node
Limbus fossa ovalis
Fossa ovalis
Valve of inferior vena cava
Inferior vena cava
Valve of coronary sinus
Opening of right atrioventricular valve

FIGURE 3.21 ■ Internal features of the right atrium. Anterior view.

6. Use a pair of forceps to grasp the free edge of the flap of atrial wall and gently pull it to the left to open the right atrium widely.
7. Remove the blood clots from the right atrium using forceps and, if permitted, take the heart to the sink to rinse the right atrium with water.
8. On the inner surface of the **anterior wall of the right atrium**, identify the **pectinate muscles** forming horizontal ridges directed at the **crista terminalis**, a vertical ridge of muscle connecting the pectinate muscles.

CLINICAL CORRELATION

#### Fossa Ovalis

ATLAS 3.54

The fossa ovalis is the remnant of the foramen ovale from embryonic development. In fetal life, blood from the placenta is delivered to the heart by passing through the liver via the remnant of the left umbilical vein, the ductus venosus, and the inferior vena cava. The oxygen and nutrient-rich blood from the placenta is directed toward the foramen ovale, which allows direct passage into the left atrium. Bypassing the right ventricle enables the enriched fetal blood to reach the body without passing through the lungs.

9. On the superior aspect of the right atrium, identify the **opening of the superior vena cava**.
10. Identify the **opening and valve of the inferior vena cava** on the inferior aspect of the right atrium.
11. On the **posterior wall of the right atrium**, identify the **opening and valve of the coronary sinus**. Insert a probe into the opening of the coronary sinus and

verify its location within the coronary sinus along the coronary sulcus.

12. On the medial aspect of the right atrium, identify the **fossa ovalis**, a small depression on the **interatrial septum**, and observe its relative location inferior to the thickened ridge of the **limbus fossa ovalis.**
13. Parts of the **conducting system of the heart** are located in the walls of the right atrium but cannot be seen in dissection. *Note that the **SA node** lies at the superior end of the crista terminalis at the junction between the right atrium and the superior vena cava, whereas the **AV node** is located in the interatrial septum superior to the opening of the coronary sinus.*
14. Identify the opening of the **right atrioventricular valve**, which leads into the right ventricle, and use a probe to observe the path of blood from the right atrium to the right ventricle.

## Right Ventricle

ATLAS 3.43, 3.55; VIDEO 3.6.2

1. Refer back to FIGURE 3.20.
2. Use a probe or your finger to determine the level of the **pulmonary valve** in the pulmonary trunk.
3. Use scissors or a scalpel to make a short horizontal cut through the **anterior wall of the right ventricle** immediately inferior to the level of the pulmonary valve (**Cut 4**).
4. Insert one blade of the scissors into the right end of the horizontal incision (**Cut 4**), and make a cut parallel to the coronary sulcus about 1 cm from the coronary sulcus, ending at the inferior border of the heart (**Cut 5**). While beginning the cut, verify the thickness of the ventricular wall to ensure the atrioventricular valve cusp is not cut on the deep surface.
5. Insert your finger through the opening in the ventricular wall and palpate the **interventricular septum** using the LAD as a guide.
6. From the left end of the horizontal incision (**Cut 4**), make a cut toward the inferior border of the heart about 2 cm to the right of the anterior interventricular sulcus, parallel to the right side of the interventricular septum, to a level just above the right margin of the heart (**Cut 6**).
7. Refer to FIGURE 3.22.
8. Use your fingers or a pair of forceps to turn the flap of the right ventricular wall inferiorly.
9. Within the right ventricle, use forceps to carefully remove blood clots. Once the clots have been removed, gently rinse the right ventricle with water to remove any remaining loose material.
10. Identify the **opening of the right atrioventricular valve** or **tricuspid valve** and observe that it has **three cusps: anterior, septal,** and **posterior**, which are named for their respective locations.

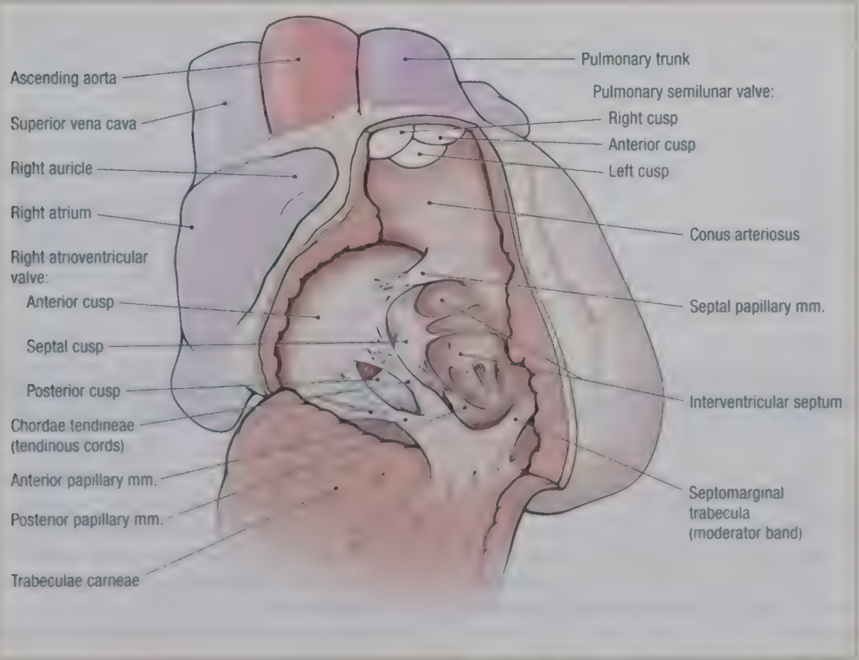

Ascending aorta
Superior vena cava
Right auricle
Right atrium
Right atrioventricular valve:
Anterior cusp
Septal cusp
Posterior cusp
Chordae tendineae (tendinous cords)
Anterior papillary mm.
Posterior papillary mm.
Trabeculae carneae
Pulmonary trunk
Pulmonary semilunar valve:
Right cusp
Anterior cusp
Left cusp
Conus arteriosus
Septal papillary mm.
Interventricular septum
Septomarginal trabecula (moderator band)

FIGURE 3.22 ■ Internal features of the right ventricle. Anterolateral view.

11. Identify the **chordae tendineae** and observe that these delicate tendons pass from the valve cusps to the apices of **papillary muscles** arising from the walls of the right ventricle.
12. Identify the **three papillary muscles** beginning with the **anterior papillary muscle**, which is the largest and easiest to identify. The **septal papillary muscle** is very small and may actually be multiple smaller muscles arising from the interventricular septum, whereas the **posterior papillary muscle** lies deep within the chamber. *Note that the chordae tendineae of each papillary muscle attach to the adjacent sides of two valve cusps.*
13. Identify the **trabeculae carneae**, the roughened muscular ridges on the inner surface of the wall of the right ventricle.
14. Identify the **septomarginal trabecula (moderator band)** near the inferior extent of the right ventricle arching from the interventricular septum to the base of the anterior papillary muscle. *Note that the septomarginal trabecula contains the part of the right bundle of the conducting system that stimulates the anterior papillary muscle.*
15. Identify the **opening of the pulmonary trunk** superiorly within the right ventricle and observe the smooth cone-shaped region named the **conus arteriosus**, or **infundibulum**, inferior to the opening.
16. Observe that the **pulmonary valve** consists of **three semilunar cusps: anterior, right**, and **left**.
17. Look into the pulmonary trunk from a superior view and examine the superior surface of the pulmonary valve. Observe that each semilunar valve cusp has one fibrous **nodule** and two **lunules**, which help to seal the valve cusps and prevent backflow of blood during diastole.

## Left Atrium

ATLAS 3.56; VIDEO 3.6.3

1. Refer to FIGURE 3.23.
2. Examine the posterior surface of the heart and observe the openings of the **four pulmonary veins** into the left atrium. The pulmonary veins are usually arranged in pairs: two from the right lung and two from the left lung.
3. Use scissors to make an inverted U-shaped cut through the posterior wall of the left atrium using the openings of the pulmonary veins as reference points laterally.
4. Use a pair of forceps to grasp the free edge of the flap and gently pull it inferiorly.
5. Remove the large blood clots within the left atrium and then gently rinse out any remaining clots with water.
6. Identify the **opening into the left auricle** observing that its inner surface is covered with pectinate muscle, while the rest of the inner surface of the left atrium is smooth.
7. Identify the **valve of the foramen ovale on the interatrial septum** in the left atrium.

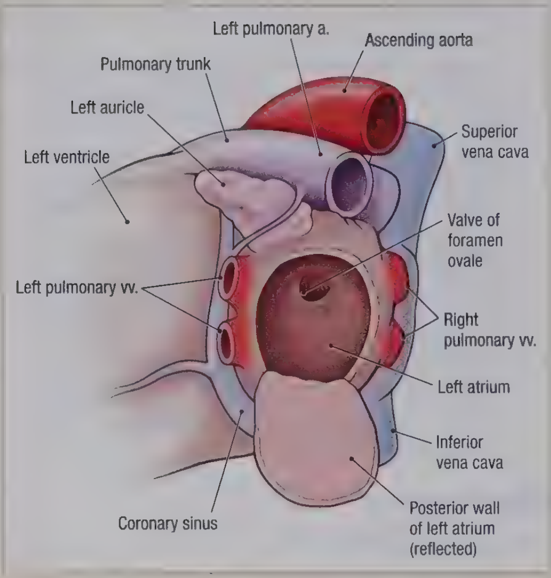


FIGURE 3.23 ■ Internal features of the left atrium. Posterolateral view.

8. Place your finger on the surface of the interatrial septum within the left atrium, and your thumb on the surface of the interatrial septum within the right atrium, and verify the relative thinness of the fossa ovale compared to the rest of the interatrial septum.
9. Identify the **opening of the left atrioventricular valve** and use a probe to observe the path of blood from the left atrium to the left ventricle.

## Left Ventricle

ATLAS 3.57, 3.59; VIDEO 3.6.4

***Dissection Note:*** The following procedure will cut the anterior interventricular branch of the left coronary artery and the great cardiac vein. Alternate approaches may be taken to spare these vessels.

1. Refer back to FIGURE 3.20.
2. Look into the aorta from a superior view and identify the **aortic valve** and its **three semilunar valve cusps: right, left**, and **posterior**.
3. Insert one blade of the scissors between the left and right semilunar cusps and make a cut inferiorly through the anterior wall of the ascending aorta anterior and parallel to the left coronary artery (**Cut 7**).
4. Cut through the junction of the ascending aorta and left ventricle and bisect the anterior interventricular branch of the left coronary artery and the great cardiac vein.
5. Continue the cut to the apex of the heart about 2 cm to the left of the anterior interventricular sulcus, making it parallel to the left side of the interventricular septum.

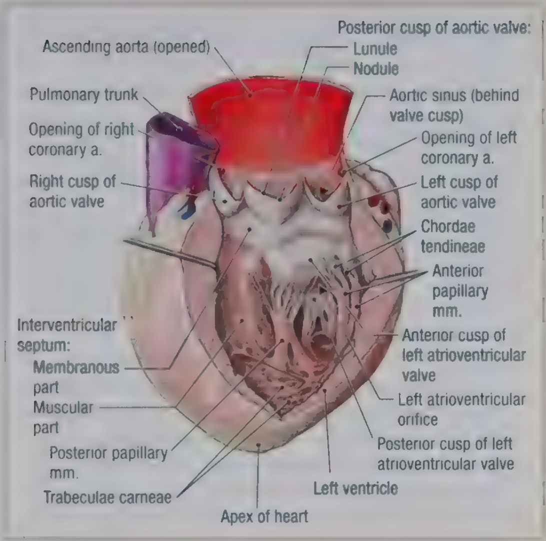

Posterior cusp of aortic valve:
Lunule
Nodule
Ascending aorta (opened)
Pulmonary trunk
Aortic sinus (behind valve cusp)
Opening of right coronary a.
Opening of left coronary a.
Right cusp of aortic valve
Left cusp of aortic valve
Chordae tendineae
Anterior papillary mm.
Interventricular septum:
Membranous part
Muscular part
Anterior cusp of left atrioventricular valve
Left atrioventricular orifice
Posterior papillary mm.
Posterior cusp of left atrioventricular valve
Trabeculae carneae
Left ventricle
Apex of heart

FIGURE 3.24 ● Internal features of the left ventricle. Oblique anterior view.

6. Refer to FIGURE 3.24.
7. Open the left ventricle and the ascending aorta widely.
8. Use forceps to carefully remove blood clots in the left ventricle. Once the majority of the clots have been removed, gently rinse the left ventricle with water to remove the remaining clots.
9. In the left ventricle, identify the **left atrioventricular valve (bicuspid valve, mitral valve)**. Distinguish the **anterior cusp** from the **posterior cusp**.
10. Identify the **anterior papillary muscle** and the **posterior papillary muscle** and observe that the **chordae tendineae** of each papillary muscle attach to both valve cusps.
11. Observe that the inner surface of the wall of the left ventricle is roughened by **trabeculae carneae**.
12. Examine the split **aortic valve** and identify its **right**, **left**, and **posterior semilunar cusps** observing that each has one nodule and two lunules.
13. Superior to the aortic valve, identify the openings of the **coronary arteries** and study their relationship to the semilunar valve cusps and the **aortic sinuses**. *Note that the posterior cusp is also called the* ***noncoronary cusp*** *because there is no coronary artery arising from its sinus.*
14. Palpate the **muscular part of the interventricular septum** and observe its thickness by placing the thumb of your right hand in the right ventricle and your index finger in the left ventricle.
15. Move your thumb and index finger superiorly along the interventricular septum and palpate the thin **membranous part of the interventricular septum** inferior to the attachment of the right cusp of the aortic valve.

## Dissection Follow-up

1. Review the internal features of each of the chambers of the heart.
2. Review the course of blood as it passes through the chambers and valves of the heart beginning in the superior vena cava and ending in the ascending aorta.
3. Review the connections of the great vessels to the various chambers of the heart.
4. Review the conducting system of the heart.
5. Replace the heart back into the thorax, and return the anterior thoracic wall to anatomical position.
6. Familiarize yourself with the heart valve locations on the surface of the anterior thoracic wall.
7. Locate the auscultation point for each heart valve on the anterior thoracic wall.

# SUPERIOR MEDIASTINUM

## Dissection Overview

The superior mediastinum is located superior to the plane connecting the sternal angle anteriorly and the intervertebral disc between vertebral bodies T4 and T5. The superior mediastinum contains structures that pass between the thorax and the neck, the thorax and the upper limb, or the thorax and the abdomen, including several of the great vessels and their primary branches, the trachea, the esophagus, and the thoracic duct.

The order of dissection will be as follows: The brachiocephalic veins will be studied and cleaned to expose the aortic arch. The aortic arch and the proximal ends of its branches will be dissected. The distal parts of these vessels will be dissected with the neck or the upper limb. The trachea and its bifurcation will be studied. The upper part of the esophagus and the vagus nerves will be dissected.

# Dissection Instructions

## Superior Mediastinum

ATLAS 3.60, 3.61; VIDEO 3.7.1

1. Refer back to FIGURE 3.13.
2. Review the **boundaries of the superior mediastinum** beginning with the **superior boundary** of the superior thoracic aperture and the **inferior boundary** of the plane of the sternal angle. The **anterior boundary** of the superior mediastinum is the manubrium of the sternum, and the **posterior boundary** is the bodies of vertebrae T1–T4. Laterally, the superior mediastinum is bound by right and left mediastinal pleurae.
3. Remove the anterior thoracic wall.
4. Identify the **thymus**, an organized fatty mass that lies immediately posterior to the manubrium of the sternum. The thymus can be recognized in the cadaver by the thymic veins on its posterior surface, which drain to the brachiocephalic veins. In the newborn, it is an active lymphatic organ that can be easily visualized on a chest radiograph.
5. Reflect the infrahyoid muscles superiorly, the thin layer of muscles extending from the neck down into the superior aspect of the superior mediastinum.
6. Remove the thymus from the superior mediastinum by blunt dissection.
7. Refer to FIGURE 3.25.
8. Identify and clean the **superior vena cava** and follow it superiorly until its two tributaries, the **left and right brachiocephalic veins**, are visible. *Note that the two brachiocephalic veins meet to form the superior vena cava posterior to the inferior border of the right first costal cartilage.*
9. Use blunt dissection to clean the left and right brachiocephalic veins and free them from the structures that lie posterior.
10. Follow the superior vena cava inferiorly and observe that it passes anterior to the superior aspect of the root of the right lung.
11. Identify and clean the **azygos vein** on the right side of the mediastinum. Observe that the **arch of the azygos vein** passes superior to the root of the right lung and drains into the posterior side of the superior vena cava.
12. Cut the left brachiocephalic vein just lateral to the superior vena cava and reflect the superior vena cava and the attached right brachiocephalic and azygos veins to the right. Reflect the left brachiocephalic vein superiorly and to the left.
13. Identify the **right** and **left phrenic nerves** where they were previously dissected in the middle mediastinum. Recall that the phrenic nerves pass anterior to the roots of the right and left lungs, respectively.
14. Follow the phrenic nerves superiorly and observe that they pass posterior to the brachiocephalic veins.
15. Clean the phrenic nerves along their full extent, from the level of the thoracic inlet to where they enter the superior surface of the diaphragm and demonstrate that they accompany the pericardiacophrenic vessels.
16. Identify and clean the **arch of the aorta**, which begins and ends at the level of the sternal angle.
17. On the superior aspect of the arch of the aorta, identify and clean its branches, from anterior to posterior, the **brachiocephalic trunk**, the **left common carotid artery**, and the **left subclavian artery**.
18. Identify the ligamentum arteriosum, the fibrous cord that connects the concavity of the arch of the aorta to the left pulmonary artery.
19. Identify the **left vagus nerve** and the **left recurrent laryngeal nerve** on the left side of the arch of the aorta. Note the relationship of the left recurrent laryngeal nerve to the ligamentum arteriosum.

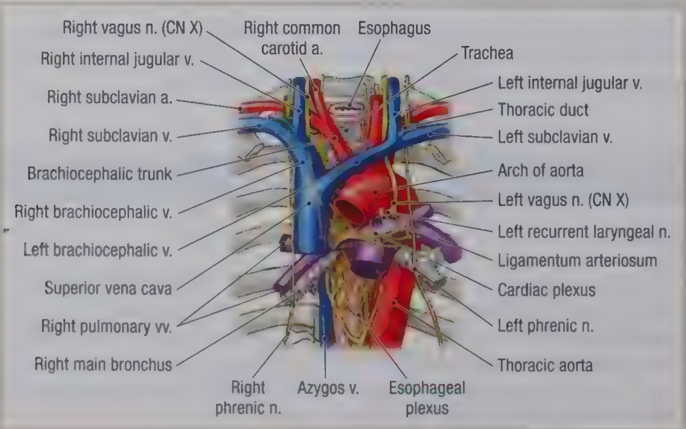

Right vagus n. (CN X)
Right internal jugular v.
Right subclavian a.
Right subclavian v.
Brachiocephalic trunk
Right brachiocephalic v.
Left brachiocephalic v.
Superior vena cava
Right pulmonary vv.
Right main bronchus
Right common carotid a.
Esophagus
Trachea
Left internal jugular v.
Thoracic duct
Left subclavian v.
Arch of aorta
Left vagus n. (CN X)
Left recurrent laryngeal n.
Ligamentum arteriosum
Cardiac plexus
Left phrenic n.
Thoracic aorta
Right phrenic n.
Azygos v.
Esophageal plexus

FIGURE 3.25 ■ Contents of the superior mediastinum. Anterior view.

CLINICAL CORRELATION

### Left Recurrent Laryngeal Nerve

ATLAS 3.60, 3.74

The left recurrent laryngeal nerve has a close relationship to the aortic arch as it passes through the superior mediastinum. In cases of mediastinal tumors or an aneurysm of the aortic arch, the left recurrent laryngeal nerve may be compressed. Compression of the left recurrent laryngeal nerve results in paralysis of the left vocal fold and hoarseness.

20. Follow and clean the left vagus nerve inferiorly and note that it passes posterior to the root of the left lung along its path toward the esophagus.
21. Refer to FIGURE 3.26.
22. On the right side of the superior mediastinum, note that the **right vagus nerve** passes posterior to the root of the right lung.
23. Identify and clean the inferior aspect of the **right recurrent laryngeal nerve**, a branch of the right vagus nerve, which loops around the right subclavian artery. *Note that if the right upper limb has not been dissected, the right subclavian artery will not be readily visible.*

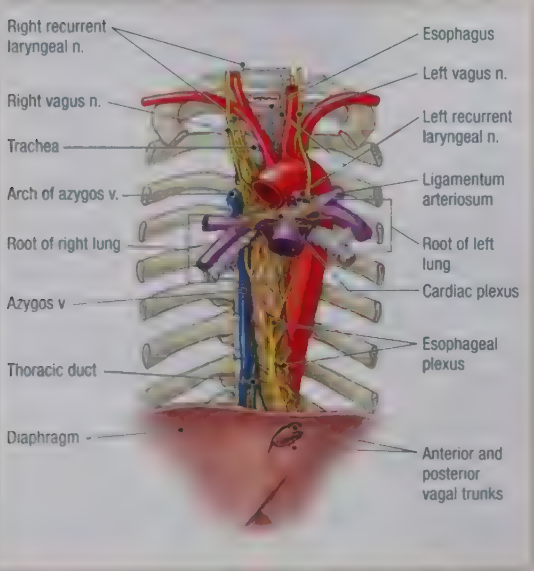


FIGURE 3.26 ● Branches of the arch of the aorta with brachiocephalic veins removed. Anterior view.

24. Identify the **trachea** and observe that the esophagus lies directly posterior to it in the superior mediastinum. Do not attempt to dissect it.
25. At the plane of the sternal angle, identify the **bifurcation of the trachea** into the **right main bronchus** and the **left main bronchus**. Use blunt dissection to clean these structures.
26. Observe that the arch of the azygos vein passes superior to the right main bronchus and the arch of the aorta passes superior to the left main bronchus.
27. Look for **tracheobronchial lymph nodes** located between the two main bronchi at the bifurcation of the trachea.
28. Palpate the anterior and posterior surfaces of the trachea near its bifurcation. You can feel that the **tracheal rings** are C-shaped with the open part of the "C" located posteriorly.

CLINICAL CORRELATION

### Bifurcation of the Trachea

ATLAS 3.63

During bronchoscopy, the carina serves as an important landmark because it lies between the superior ends of the right and left main bronchi. The carina is usually positioned slightly to the left of the median plane of the trachea. When foreign bodies are aspirated, they usually enter the right main bronchus because it is wider and more vertically oriented than the left main bronchus.

29. Observe that the esophagus is located posterior to the trachea in close relationship to the open part of the tracheal cartilages.
30. Compare the right and left main bronchi and observe that the right main bronchus is larger in diameter, shorter, and oriented more vertically than the left main bronchus.
31. Use an image to study the inner surface of the tracheal bifurcation or carefully make an inverted "Y"-shaped cut following the branching pattern of the main bronchi. Observe that inside the trachea, at the inferior border of the tracheal bifurcation, is a ridge of cartilage called the **carina**.
32. Identify and clean the pulmonary trunk to its bifurcation point into the **right and left pulmonary arteries**. Observe that the right pulmonary artery passes posterior to the superior vena cava and that the left pulmonary artery passes anterior to the **descending (thoracic) aorta**.

## Dissection Follow-up

1. Review the formation of the superior vena cava and the position of the arch of the azygos vein.
2. Review the position of the ascending aorta, the arch of the aorta, and its branches.
3. Compare the positions of the phrenic and vagus nerves relative to the root of the lung.
4. Contrast the thoracic course of the left recurrent laryngeal nerve with the cervical course of the right recurrent laryngeal nerve. Relate these differences in pathway to the embryonic origin of the arteries.
5. Replace the contents of the superior mediastinum into their correct anatomical positions.
6. Return the anterior thoracic wall to its correct anatomical position and project the structures of the superior mediastinum to the surface of the thoracic wall.

# POSTERIOR MEDIASTINUM

## Dissection Overview

The posterior mediastinum lies posterior to the pericardium and contains structures that course between the neck and thorax and between the thorax and abdomen. To emphasize their close relationship to the heart, the structures in the posterior mediastinum will be approached through the posterior wall of the pericardium.

The order of dissection will be as follows: The pericardium will be reviewed, and its posterior wall removed. The esophagus will be studied. The azygos vein and its tributaries will be studied. The thoracic duct will be identified. The descending aorta and its branches will be dissected. The thoracic portion of the sympathetic trunk and its branches will be dissected.

## Dissection Instructions

### Posterior Mediastinum

ATLAS 3.46B, 3.46C, 3.69, 3.70; VIDEO 3.8.1

1. Refer back to FIGURE 3.13.
2. The **posterior mediastinum** has its **superior boundary** at the plane of the sternal angle, its **inferior boundary** at the diaphragm, its **anterior boundary** at the pericardium, its posterior boundary at the bodies of vertebrae T5–T12, and its **lateral boundaries** at the right and left mediastinal pleurae.
3. Place the heart in the pericardial cavity and examine the relationship of the heart to the esophagus from the right side of the thorax. *Note that the esophagus lies immediately posterior to the left atrium and part of the left ventricle.*
4. Remove the heart from the pericardial cavity.
5. Use your fingers to gently separate the esophagus from the posterior aspect of the pericardium.
6. Refer to FIGURE 3.27.
7. Use scissors to carefully make a vertical cut through the posterior wall of the pericardium in the **area of the oblique pericardial sinus.**
8. Spread the posterior wall of the pericardium and identify the **esophagus,** a muscular tube just to the right of the midline.
9. Identify the large **thoracic aorta** to the left and slightly posterior to the esophagus coursing inferiorly through the posterior mediastinum.

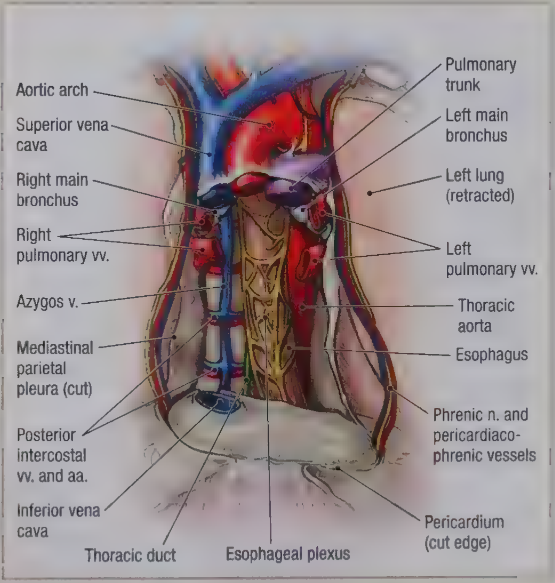

Aortic arch
Superior vena cava
Right main bronchus
Right pulmonary vv.
Azygos v.
Mediastinal parietal pleura (cut)
Posterior intercostal vv. and aa.
Inferior vena cava
Thoracic duct
Esophageal plexus
Pulmonary trunk
Left main bronchus
Left lung (retracted)
Left pulmonary vv.
Thoracic aorta
Esophagus
Phrenic n. and pericardiacophrenic vessels
Pericardium (cut edge)

FIGURE 3.27 ■ Contents of the posterior mediastinum. Anterior view.

10. Use blunt dissection to elevate and reflect the remainder of the posterior wall of the pericardium leaving the portion adhering to the diaphragm undisturbed.
11. Use scissors to cut the pericardium near its attachments to the great vessels and diaphragm and place the pericardium in the tissue container.

12. Use blunt dissection to clean the **esophagus** and observe that the surface of the esophagus is covered by the **esophageal plexus of nerves**, which innervates the inferior portion of the esophagus.
13. Find the **right vagus nerve** where it crosses the anterior surface of the right subclavian artery and follow it posterior to the root of the right lung. Use blunt dissection to demonstrate that the fibers of the right vagus nerve spread out on the surface of the esophagus.
14. Identify the **left vagus nerve** as it crosses the left side of the arch of the aorta and follow it posterior to the root of the left lung. Use blunt dissection to demonstrate that its fibers contribute to the esophageal plexus.
15. Note that the esophageal plexus condenses to form the **anterior vagal trunk** on the anterior surface of the esophagus and the **posterior vagal trunk** on the posterior surface of the esophagus, just superior to the esophageal hiatus in the diaphragm. *Note that due to the curvature of the diaphragm, the vagal trunks may not be visible at this stage of the dissection.*
16. Identify the **azygos vein** where it arches superior to the root of the right lung and follow it inferiorly to the level of the diaphragm.
17. Refer to FIGURE 3.28.
18. Clean the azygos vein on the right side of the thorax as well as the **posterior intercostal veins**, which drain into it.
19. Retract the esophagus to the left and explore the area between the **azygos vein** and the **thoracic aorta** and identify the **thoracic duct**, which has the appearance of a small vein without blood in it. Observe that the thoracic duct lies posterior to the esophagus between the azygos vein and the aorta.
20. Use blunt dissection to carefully free the thoracic duct from the surrounding connective tissue, paying attention because it is thin walled and easily torn. *Note that the thoracic duct may be a network of several smaller ducts instead of a single duct.*
21. Follow the thoracic duct inferiorly to where it passes through the diaphragm with the thoracic aorta.
22. Observe that the thoracic duct crosses the anterior surface of the **right posterior intercostal arteries**, the **hemiazygos vein**, and the **accessory hemiazygos vein**. *Note that superiorly, the thoracic duct terminates by draining into the junction of the left internal jugular vein and left subclavian vein. Do not attempt to demonstrate its superior termination at this time.*
23. On the left side of the posterior thorax, clean the **hemiazygos vein** inferiorly and the **accessory hemiazygos vein** superiorly. Identify and clean a few posterior intercostal veins that drain into the azygos system.
24. Follow the accessory hemiazygos and hemiazygos veins across the bodies of the eighth and ninth thoracic vertebrae, respectively and observe that they terminate by draining into the azygos vein. *Note that variations of the azygos system are common.*

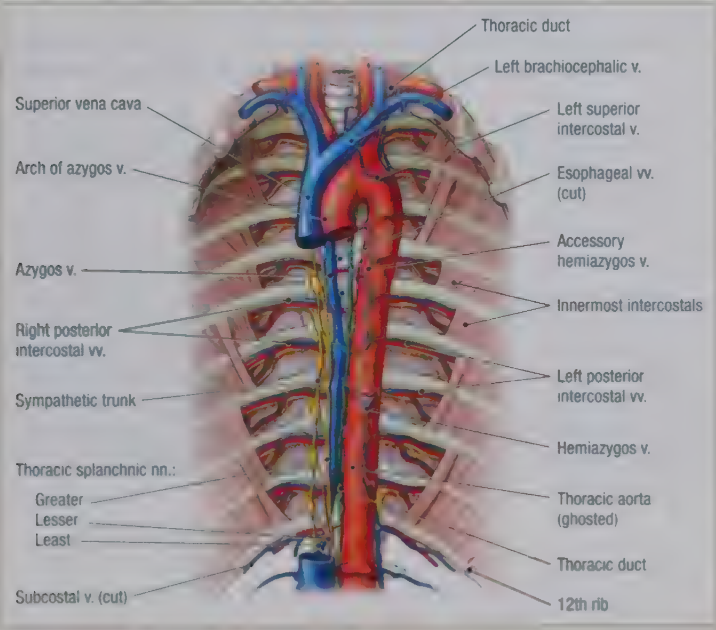
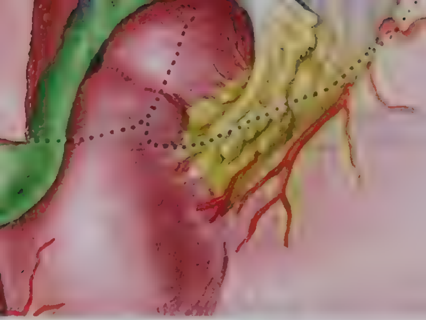

Thoracic duct
Left brachiocephalic v.
Superior vena cava
Left superior intercostal v.
Arch of azygos v.
Esophageal vv. (cut)
Accessory hemiazygos v.
Azygos v.
Innermost intercostals
Right posterior intercostal vv.
Left posterior intercostal vv.
Sympathetic trunk
Hemiazygos v.
Thoracic splanchnic nn.:
Greater
Lesser
Least
Thoracic aorta (ghosted)
Thoracic duct
Subcostal v. (cut)
12th rib

FIGURE 3.28 ● Azygos system and sympathetic trunk. Anterior view.

25. Examine the branches of the **thoracic aorta**. Identify and clean the **esophageal arteries** on the deep surface of the esophagus and the **left bronchial arteries** coursing along the main bronchi (if visible). *Note that the left bronchial arteries arise from the anterior surface of the aorta, whereas the right bronchial arteries may arise from intercostal arteries, the thoracic aorta, or the left bronchial arteries and are distinguished by their area of distribution.*
26. Dissect one pair of **posterior intercostal arteries** (right and left) and follow them to their intercostal space. Observe that the right posterior intercostal arteries cross the midline on the anterior surface of the vertebral bodies and pass posterior to all other contents of the posterior mediastinum.
27. On both sides of the thorax, identify and clean one **intercostal nerve** and follow it laterally until it disappears posterior to the **innermost intercostal muscle**.
28. On both sides of the thorax, identify the **sympathetic trunk (chain)**.
29. Starting high in the thorax, clean and follow the sympathetic trunk inferiorly and observe that it crosses the heads of ribs 2 to 9.
30. Inferior to rib 9, observe that the sympathetic trunk lies more anteriorly, on the sides of the thoracic vertebral bodies.
31. Observe that the sympathetic trunk has one **sympathetic ganglion** for each thoracic vertebral level.
32. Demonstrate that two **rami communicantes (white ramus communicans** and **gray ramus communicans)** connect each intercostal nerve with its corresponding thoracic sympathetic ganglion. *Note that during dissection, it is impossible to distinguish white and gray rami from each other based on color; however, the more lateral of the two rami is the white ramus communicans.*
33. Use a probe to clean the contributions to the **greater splanchnic nerves** arising on both the right and left sides from the respective sympathetic trunk. Follow the contributions from the fifth through the ninth thoracic sympathetic ganglia on the lateral surfaces of vertebral bodies T5–T9 and observe that the greater splanchnic nerves are not completely formed until lower thoracic levels.
34. The **lesser splanchnic nerves** arise from the 10th and 11th thoracic sympathetic ganglia, and the **least splanchnic nerves** arise from the 12th thoracic sympathetic ganglion. Due to the curvature of the diaphragm, these two pairs of nerves cannot be seen at this time.

## Dissection Follow-up

1. Review the boundaries of the anterior, middle, and posterior mediastina.
2. Study a transverse section through the midlevel of the thorax and identify the contents of the posterior mediastinum and observe the relationship of the contents of the posterior mediastinum to the heart and vertebral bodies.
3. Review the course and function of an intercostal nerve, naming all structures that it innervates.
4. Review the parts of the aorta (ascending, arch, and thoracic), naming all branches derived from each region and their areas of distribution.
5. Review the origin and course of the right and left posterior intercostal arteries.
6. Name the structures in the posterior mediastinum that cross anterior to the right posterior intercostal arteries.
7. Replace the contents of the posterior mediastinum, the heart, the lungs, and the anterior thoracic wall to anatomical position.



## CHAPTER 4

# The Abdomen

**REFERENCES**

ATLAS = *Grant's Atlas of Anatomy*, 15th ed., figure number

VIDEO = *Grant's Dissection Videos*, video sequence number

The abdomen is the portion of the trunk between the thorax and the pelvis. Superiorly, the abdominal cavity is physically divided from the thoracic cavity by the diaphragm. Inferiorly, the abdominal cavity is continuous with the pelvic cavity, and thus, they are commonly referred to collectively as the abdominopelvic cavity. As the abdominal organs (viscera) are not bilaterally symmetrical, it is worth noting that use of the words "right" and "left" in names and instructions refers to the right and left sides of the cadaver in the anatomical position.

Unlike the thoracic cavity where the contents were protected by the thoracic cage, the contents of the abdominal cavity are not protected by bony structures anteriorly or laterally. Although the muscular anterolateral abdominal wall offers less protection than the thoracic cage, it adds the benefit of increased body movement. Additionally, the abdominal muscles are able to increase intra-abdominal pressure to assist in voiding of the bowels, vomiting, childbirth, and respiration.

### CLINICAL CORRELATIONS

During the course of your dissection protocol, you may encounter anatomical variations, clinical conditions, disease processes, or medical devices in your cadaveric donor. The following select clinical correlations will be described in more detail throughout this chapter.

**The Abdomen**

1. Superficial Veins of the Abdominal Wall, see the **Superficial Fascia of the Abdomen** sequence. ATLAS 4.7
2. Inguinal Hernias, see the **Transversus Abdominis Muscle** sequence. ATLAS 4.18
3. Epigastric Artery Anastomoses, see the **Epigastric Vessels and Deep Inguinal Ring** sequence. ATLAS 4.5
4. Anatomical Variation in Cystic Arteries, see the **Celiac Trunk** sequence. ATLAS 4.57A, 4.62
5. Lacerated Spleen and Splenomegaly, see the **Spleen** sequence. ATLAS 4.35
6. Liver Enlargement, see the **Liver** sequence. ATLAS 4.55
7. Superior Mesenteric Artery Syndrome, see the **Superior Mesenteric Artery and Vein** sequence. ATLAS 4.68
8. Appendicitis, see the **Large Intestine** sequence. ATLAS 4.43
9. Portal Hypertension, see the **Hepatic Portal Vein** sequence. ATLAS 4.66
10. Testicular Varicocele, see the **Retroperitoneal Vasculature** sequence. ATLAS 4.19, 4.68
11. Kidney Stones, see the **Kidneys** sequence. ATLAS 4.70
12. Suprarenal Gland Development, see the **Suprarenal (Adrenal) Glands** sequence. ATLAS 4.70
13. Diaphragmatic Hernias, see the **Diaphragm** sequence. ATLAS 4.79

# SUPERFICIAL FASCIA OF THE ANTEROLATERAL ABDOMINAL WALL

## Dissection Overview

The superficial fascia is unique in the abdominal region in that it forms two distinct layers as you progress inferiorly: the Camper's fascia, a superficial fatty layer, and the Scarpa's fascia, a deep membranous layer. The membranous layer is noteworthy because it attaches to the fascia lata of the thigh and is continuous with named fasciae in the perineum.

Deep to the superficial fascia laterally, three broad flat muscles course around the abdominal wall to reach the midline via thin aponeurotic extensions. On the deep surface of the muscular wall, the transversalis fascia surrounds the abdominal cavity along with an additional layer of fatty tissue and the parietal peritoneum as illustrated in FIGURE 4.1.

The order of dissection will be as follows: The skeletal anatomy of the abdomen will be studied. The surface anatomy of the abdomen and the abdominal subdivisions into either quadrants or regions will be studied. The skin will be either reflected or removed from the abdomen. The subcutaneous tissue will either be removed or reflected in a full- or partial-thickness approach. Neurovascular structures in the abdomen will be studied.

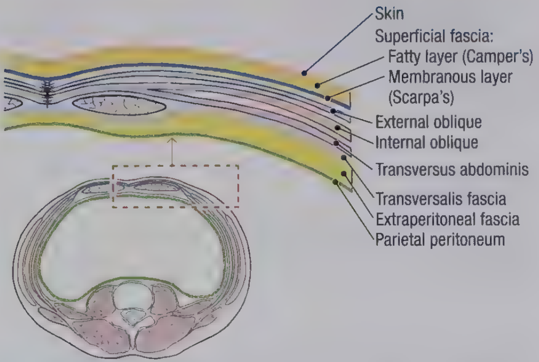

Skin
Superficial fascia:
Fatty layer (Camper's)
Membranous layer (Scarpa's)
External oblique
Internal oblique
Transversus abdominis
Transversalis fascia
Extraperitoneal fascia
Parietal peritoneum

FIGURE 4.1 ■ Axial section of lower abdomen demonstrating the layers of the anterior abdominal wall. Inferior view.

### Skeletal Anatomy

Use an articulated skeleton to identify the following structures.

#### *Sternum and Costal Margin*

ATLAS 3.10

1. Refer to FIGURE 4.2.
2. In the midline, identify the **xiphoid process**, the extension of bone inferior to the **body of the sternum**. *Note that although the xiphoid is often triangular in shape, it may appear bifid or split in some individuals.*
3. Identify the location of the **xiphisternal junction** at the intersection of the body of the sternum and the xiphoid process.
4. On the lateral aspects of the xiphisternal junction, identify the **costal cartilages** of the false ribs merging to form the **costal margin** and observe that the junction is near the level of the 6th costal cartilage.

#### *Bony Pelvis*

ATLAS 5.3, 5.4

1. In the midline of the bony pelvis, identify the junction of the **right** and **left pubic bones** at the **pubic symphysis**.
2. Identify the **pubic crest** coursing laterally from the pubic symphysis on the superior aspect of the pubic bones.
3. On the lateral aspect of the pubic crest, identify the **pubic tubercle**, the medial attachment of the **inguinal ligament**.
4. The inguinal ligament courses from the pubic tubercle laterally and superiorly to the **anterior superior iliac spine (ASIS)** of the **ilium**.

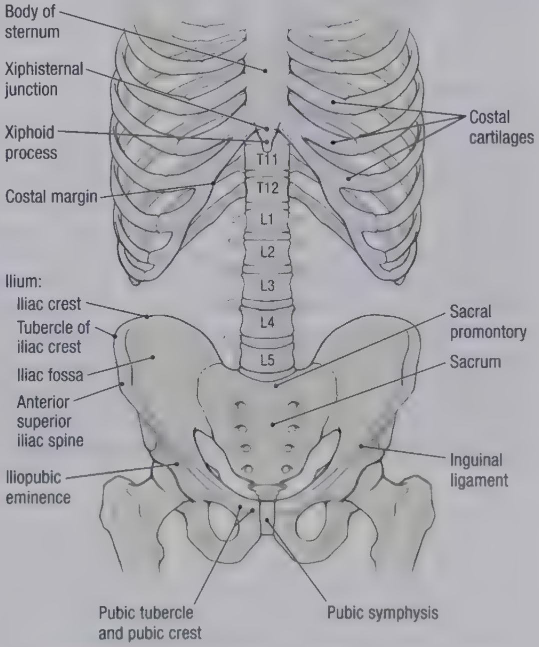

Body of sternum
Xiphisternal junction
Xiphoid process
Costal margin
Costal cartilages
T11
T12
L1
L2
L3
L4
L5
Ilium:
Iliac crest
Tubercle of iliac crest
Iliac fossa
Anterior superior iliac spine
Iliopubic eminence
Sacral promontory
Sacrum
Inguinal ligament
Pubic tubercle and pubic crest
Pubic symphysis

FIGURE 4.2 ■ Abdominal skeleton. Anterior view.

5. Identify the ASIS along the anterior aspect of the ilium and follow the bony ridge of the **iliac crest** posteriorly toward the midaxillary line.
6. Identify the **iliac tubercle** approximately midway along the length of the iliac crest near the midaxillary line.

## Surface Anatomy

The surface anatomy of the abdomen may be studied on a living subject or on a cadaver. On the cadaver, note that fixation of tissue during embalming may make it difficult to distinguish bone from well-preserved soft tissues in some specimens.

### Abdomen

ATLAS 4.2

1. Refer to FIGURE 4.3.
2. With the cadaver in the supine position, palpate the **xiphoid process** in the midline, just below the **xiphisternal junction**.
3. At the midpoint of the abdomen, identify the **umbilicus**.
4. Trace your finger inferiorly along the midline from the umbilicus to the **pubic symphysis**.
5. Palpate laterally from the pubic symphysis along the **pubic crest** to the **pubic tubercle**.
6. Use your finger to trace the path of the **inguinal ligament** from the pubic tubercle, superolaterally, to the palpable ASIS on the anterior aspect of the hip.

### Abdominal Subdivisions

ATLAS 4.3

The quadrant and regional systems are both commonly used and rely on surface anatomy for proper orientation. The quadrant system is suitable for general descriptions and will be used to describe the position of organs in this dissection guide.

1. Refer to FIGURE 4.4.
2. Use your fingers to trace the planes used in the **quadrant system** to subdivide the abdominal cavity.
3. Identify the location of the **median plane** beginning superiorly at the body of the sternum and xiphoid process.
4. Progress inferiorly along the linea alba past the umbilicus until you reach the pubic symphysis. *Note that depending on the amount of abdominal subcutaneous tissue that the linea alba and pubic symphysis may not be easily palpable.*
5. Return to the umbilicus and identify the location of the horizontally oriented **transumbilical plane**.
6. Identify the **right** and **left upper quadrants** superior to the transumbilical plane to the right and left sides of the median plane, respectively.

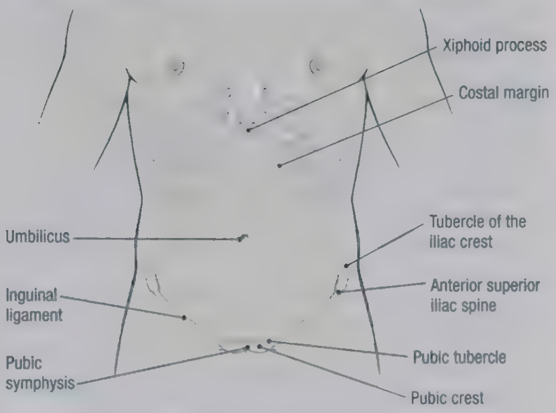

Xiphoid process
Costal margin
Umbilicus
Tubercle of the iliac crest
Inguinal ligament
Anterior superior iliac spine
Pubic tubercle
Pubic symphysis
Pubic crest

FIGURE 4.3 ■ Surface anatomy of the abdomen. Anterior view.

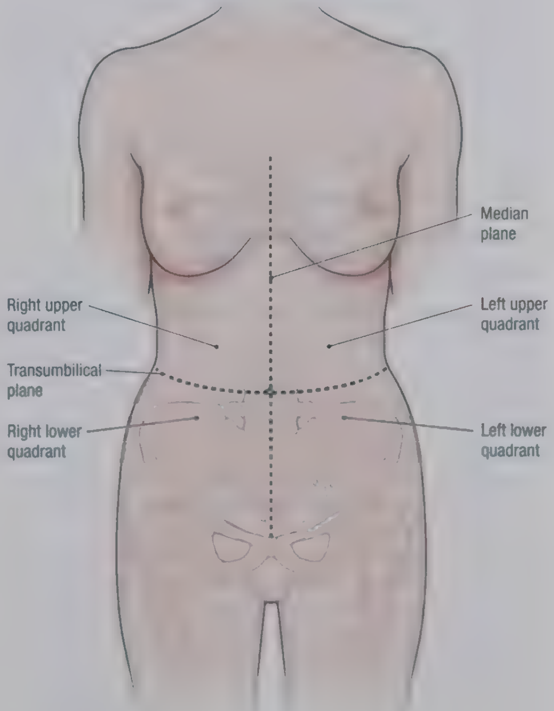

Median plane
Right upper quadrant
Left upper quadrant
Transumbilical plane
Right lower quadrant
Left lower quadrant

FIGURE 4.4 ■ Four abdominal quadrants in the female. Anterior view.

7. Identify the **right** and **left lower quadrants** superior to the transumbilical plane to the right and left sides of the median plane, respectively.
8. Refer to FIGURE 4.5.
9. Use your finger to trace the planes used in the **regional system** to subdivide the abdomen.
10. Begin with the vertically oriented **midclavicular lines** beginning at the midpoint of each clavicle and course inferiorly to the midpoint between the ASIS and the pubic tubercle, effectively bisecting each inguinal ligament.
11. Progressing posteriorly from the ASIS, palpate the **iliac crest** and the **iliac tubercle** located on the superolateral aspect of the ilium about 5 cm posterior to the ASIS. The **transtubercular plane** passes through the right and left iliac tubercles.
12. Return to the xiphoid process and palpate bilaterally along the **costal margin** to the lowest palpable level to identify the height of the **subcostal plane**.
13. Identify the nine abdominal regions beginning superiorly with the **right** and **left hypochondriac regions** deep to the thoracic cage to either side of the **epigastric region**.
14. Progress inferiorly to the **right** and **left lumbar regions** to either side of the **umbilical region**.
15. Continue inferiorly to the **right** and **left inguinal regions** to either side of the **hypogastric (pubic) region**. *Note that clinical complaints may be more specifically described using the regional system than the quadrant system, and thus, you should be familiar with both descriptive methods.*

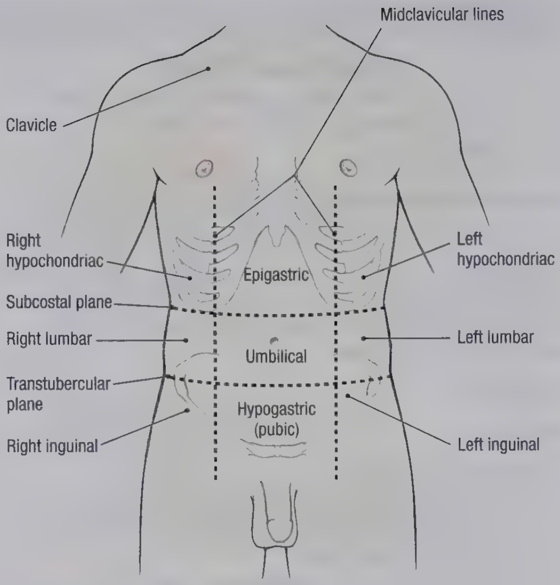


FIGURE 4.5 ■ Nine abdominal regions in the male. Anterior view.

## Dissection Instructions

### Skin Incisions of the Abdomen

VIDEO 4.1.1

***Dissection Note:*** Prior to commencing with skin incisions, decide to either perform a full- or partial-thickness approach and to either reflect or remove the skin from the dissection field. See **Removing the Skin** in the **Introduction Chapter** for descriptions.

1. Refer to FIGURE 4.6.
2. Make a midline skin incision from the xiphisternal junction (C) to the pubic symphysis (E), encircling the umbilicus.
3. Make an incision from the xiphoid process (C) along the costal margin to a point on the midaxillary line (V). *Note that if the thorax has been dissected previously, this incision has already been made.*
4. Make a skin incision beginning 3 cm inferior to the pubic crest (E) running parallel to the line of the inguinal ligament to a point 3 cm inferior to the ASIS. *Note that care must be made along this incision line as superficial structures in the region may easily be damaged, particularly in cadavers with little adipose tissue.*

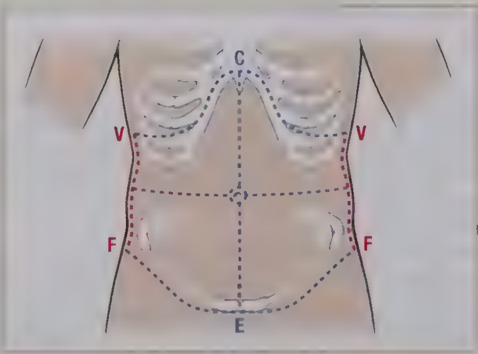


FIGURE 4.6 ■ Abdominal skin incisions. Anterior view.

5. Continue the incision posteriorly, 3 cm below the iliac crest to a point on the midaxillary line (F).
6. Make a transverse skin incision from the encircling cut around the umbilicus to each midaxillary line.
7. If reflecting the skin, use the uncut sections of skin laterally as hinge points to leave the skin attached along the peripheral aspect of the abdomen and reflect the skin only as far laterally as the midaxillary line.

8. If removing the skin, make a vertical skin incision along the midaxillary line in the thorax (V) to the tubercle of the iliac crest (F). *Note that if the back has been dissected previously, this incision has already been made.*
9. If using a partial-thickness removal method, remove the skin, but not the superficial fascia, from medial to lateral using either a pair of locking forceps or the buttonhole technique. At any point, the portions of skin may be cut into smaller segments to facilitate removal.
10. If using a full-thickness skin removal method, skip the following dissection instructions on the superficial fascia.
11. If the skin is to be removed, detach the skin along the periphery and place it in the tissue container.

## Superficial Fascia of the Abdomen

ATLAS 4.5, 4.6, 4.11B, 4.11C; VIDEO 4.1.2

1. Refer to FIGURE 4.7.
2. Just lateral to the midclavicular line in the abdominal region, create a vertical cut through the superficial fascia, about 7.5 cm lateral to the midline. *Note that the superficial epigastric artery and vein course in the superficial fascia in this area but do not make a special effort to find them.*
3. Dissect through the superficial fascia down to the **aponeurosis of the external oblique muscle.**
4. On the medial side of the vertical cut, use blunt dissection to separate the superficial fascia from the aponeurosis of the external oblique muscle (**Arrow 1**).
5. As you remove the superficial fascia inferior to the umbilicus, observe that its deep surface is fibrous connective tissue containing relatively little fat (Scarpa's fascia) and that its superficial layer is composed almost entirely of fat (Camper's fascia).
6. As you approach the midline, identify one or two **anterior cutaneous nerves** that enter the superficial fascia 2 to 3 cm lateral to the midline. *Note that the abdominal anterior cutaneous nerves are branches of intercostal nerves (T7–T11), the subcostal nerve (T12), and the iliohypogastric nerve (L1).*

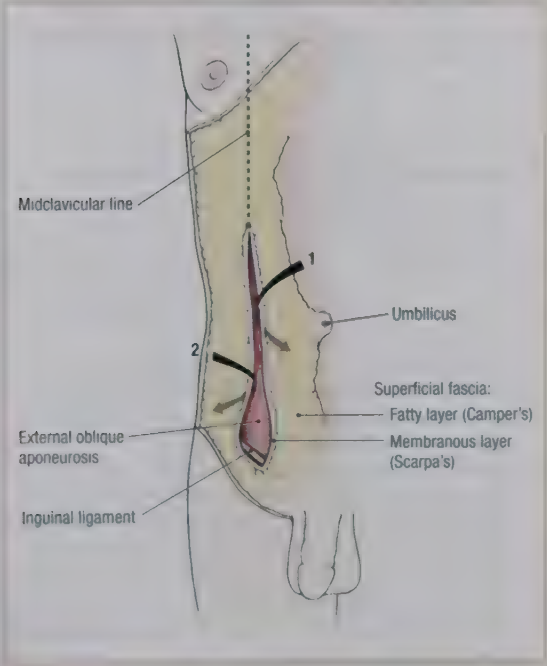


FIGURE 4.7 ● Superficial fascia of the abdomen. Anterior view.

**CLINICAL CORRELATION**

### Superficial Veins of the Abdominal Wall

ATLAS 4.7

The superficial epigastric vein anastomoses with the lateral thoracic vein in the superficial fascia of the abdomen creating an important collateral venous channel from the femoral vein to the axillary vein. In patients who have obstruction of the inferior vena cava or hepatic portal vein, the superficial veins of the abdominal wall may become engorged to accommodate increased venous return, and may be visible around the umbilicus (caput medusae).

7. While removing the superficial fascia, consult a dermatome chart and note that T6 innervates the skin superficial to the xiphoid process, T10 innervates the skin of the umbilicus, T12 innervates the skin superior to the pubic symphysis, and L1 innervates the skin overlying the pubic symphysis.
8. Lateral to the vertical cut made in step 1, use blunt dissection to separate the superficial fascia from the external oblique muscle (**Arrow 2**).
9. As you near the midaxillary line, identify the **lateral cutaneous nerves** entering the superficial fascia and clean the branches of at least one lateral cutaneous nerve. *Note that the lateral cutaneous nerves are branches of intercostal and subcostal nerves.*
10. Remove the superficial fascia from superior to inferior and clearly demonstrate the lower border of the external oblique muscle where it terminates as the **inguinal ligament**. Extend the superficial fascia removal inferiorly to a point approximately 2.5 cm into the proximal thigh.
11. Detach the superficial fascia from the midline, midaxillary line, and proximal thigh and place it in the tissue container.

## Dissection Follow-up

1. Familiarize yourself with the distribution of the superficial epigastric vessels.
2. Review the abdominal distribution of the anterior rami of spinal nerves T6–L1.
3. If a full- or partial-thickness skin reflection was performed, replace the reflected portions of skin back to anatomical position.

# MUSCLES OF THE ANTEROLATERAL ABDOMINAL WALL

## Dissection Overview

Three flat muscles (external oblique, internal oblique, and transversus abdominis) form most of the anterolateral abdominal wall. The three flat muscles have broad, fleshy proximal attachments (to the ribs, vertebrae, and pelvis) and broad, aponeurotic distal attachments (to the ribs, linea alba, and pubis). Each of the three flat muscles contributes to the formation of the rectus sheath and the inguinal canal.

The rectus abdominis muscle forms the bulk of the anterior abdominal wall from the fifth rib superiorly to the pubic crest inferiorly. Between the right and left rectus abdominis muscles lies the midline tendinous structure, the linea alba. Because there are no bones in the anterior abdominal wall, the linea alba serves as a site of muscle attachment.

In the male, the testes are housed in the scrotum, which is essentially an outpouching of the anterior abdominal wall. Each testis passes through the abdominal wall during development dragging its ductus deferens behind it. The passage of the testis occurs through the inguinal canal, superior to the medial half of the inguinal ligament, and extends from the deep (internal) inguinal ring to the superficial (external) inguinal ring.

Transversalis fascia lines the inner surface of the transversus abdominis muscles. The deep inguinal ring is the point at which the gubernaculum passed through the transversalis fascia during development. In the adult, the deep inguinal ring is located superior to the midpoint of the inguinal ligament. In the male, the ductus deferens passes through the deep inguinal ring. In the female, the round ligament of the uterus passes through the deep inguinal ring. During development of the male, the testis and all its related vessels, nerves, and ducts passed through the deep inguinal ring on the way to the scrotum.

The order of dissection will be as follows: The three flat muscles of the anterolateral abdominal wall will be studied and reflected bilaterally. The superficial inguinal ring and inguinal canal will be studied. The composition and contents of the rectus sheath will be explored. The anterior abdominal wall will be reflected.

## Dissection Instructions

### External Oblique Muscle

ATLAS 4.6, 4.8A, 4.11A; VIDEO 4.2.1

1. Refer to FIGURE 4.8A.
2. Clean any remnants of the superficial fascia from the surface of the external oblique muscles and place the fascia in the tissue container.
3. Observe the **external oblique muscle** and note that its fibers course from superolateral to inferomedial.
4. Remove a portion of the investing fascia from the surface of the external oblique muscle to better visualize the fiber direction and extent of the muscle. *Note that in thinner cadavers, removal of the overlying investing fascia may compromise the stability of the muscle.*
5. Use blunt dissection to clean the aponeurosis of the external oblique muscle and clearly delineate the **semilunar line**.
6. Review the attachments and actions of the external oblique muscle (see **TABLE 4.1**).
7. Refer to FIGURE 4.8B and C.
8. Clean the inferomedial portion of the external oblique aponeurosis and identify the opening of the **superficial inguinal ring** formed in the external oblique aponeurosis.
9. Observe that the superficial inguinal ring permits the spermatic cord in the male, and round ligament of the uterus in the female, to pass from the inguinal canal into the suprapubic region.
10. At the margins of the superficial inguinal ring, identify the **external spermatic fascia**, the thin layer of fascia that extends from the external oblique aponeurosis onto the spermatic cord.
11. Identify the **ilioinguinal nerve** emerging through the superficial inguinal ring, anterior to the spermatic cord in the male, or the round ligament of the uterus in the female. *Note that the ilioinguinal nerve supplies sensory innervation to the skin on the anterior surface of the external genitalia and medial surface of the thigh after providing motor innervation to the anterolateral abdominal wall.*
12. Observe that in the female, the ilioinguinal nerve is a useful structure to verify the location of the superficial inguinal ring because the round ligament of the uterus may be quite small and difficult to identify.

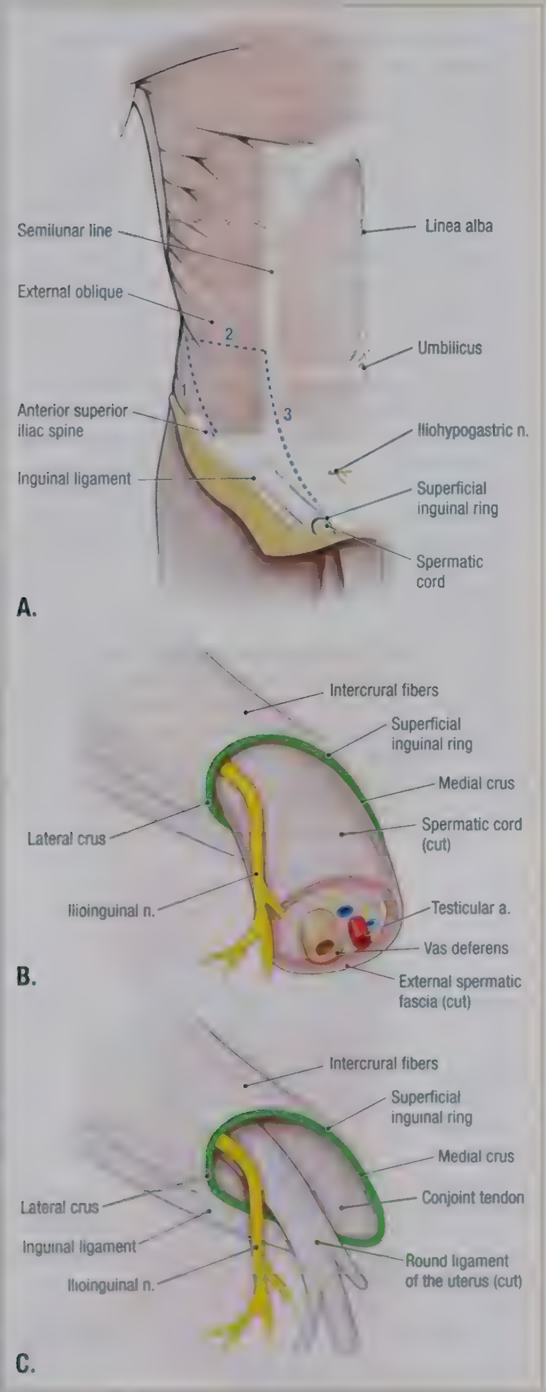

Semilunar line
External oblique
Anterior superior iliac spine
Inguinal ligament
Linea alba
Umbilicus
Iliohypogastric n.
Superficial inguinal ring
Spermatic cord
1
2
3
A.
Intercrural fibers
Superficial inguinal ring
Medial crus
Lateral crus
Spermatic cord (cut)
Ilioinguinal n.
Testicular a.
Vas deferens
External spermatic fascia (cut)
B.
Intercrural fibers
Superficial inguinal ring
Medial crus
Lateral crus
Conjoint tendon
Inguinal ligament
Ilioinguinal n.
Round ligament of the uterus (cut)
C.

FIGURE 4.8 ● **A.** Opening the abdominal wall. **B.** Right male superficial inguinal ring. **C.** Right female superficial inguinal ring. Anterior views. NOT doing this

13. Use a probe to identify the **lateral (inferior) crus** defining the lateral margin of the superficial inguinal ring. Observe that these fibers arch around the spermatic cord and attach to the pubic tubercle.
14. Identify the **medial (superior) crus** defining the medial margin of the superficial inguinal ring and observe that these fibers attach to the pubic crest.
15. Identify the **intercrural fibers**, the delicate fibers spanning the crura superolateral to the superficial inguinal ring. *Note that the intercrural fibers prevent the crura from spreading apart.*
16. Observe that the inferior border of the aponeurosis of the external oblique muscle curves posteriorly and thickens to form the **inguinal ligament** attaching from the ASIS to the pubic tubercle. *Note that large vessels and nerves that pass between the abdominal cavity and the lower limb run deep to the inguinal ligament but will not be dissected at this time.*
17. Insert a probe through the superficial inguinal ring into the inguinal canal and observe that the external oblique aponeurosis forms the anterior wall of the inguinal canal and that the inguinal ligament forms its floor.
18. Identify the **lacunar ligament** inferior to the contents of the inguinal canal and observe that it is formed at the medial end of the inguinal ligament by fibers that turn posteriorly and attach to the pecten pubis. *Note that the lacunar ligament is oriented medial to the femoral vein, artery, and nerve, which supply aspects of the thigh, and will be more visible after opening the inguinal canal.*

## Internal Oblique Muscle

ATLAS 4.8B, 4.9B; VIDEO 4.2.2

***Dissection Note:*** To expose the internal oblique muscle, the external oblique muscle will be partially transected and the resulting flap reflected inferiorly.

1. Refer to FIGURE 4.8A.
2. Make a vertical cut through the external oblique muscle beginning at the ASIS and ending at the level of the umbilicus (**Cut 1**). Make an effort to only cut the external oblique aponeurosis and none of the underlying layers by proceeding slowly and cautiously.
3. Use blunt dissection to carefully separate the external oblique from the underlying internal oblique muscle layer laterally.
4. Make a horizontal cut across the external oblique muscle stopping at the **semilunar line** (**Cut 2**). *Note that your fingers or a probe cannot pass medial to the semilunar line because the external oblique aponeurosis fuses to the underlying internal oblique aponeurosis at this location.*
5. Use blunt dissection to carefully separate the external oblique from the underlying internal oblique muscle layer superiorly.

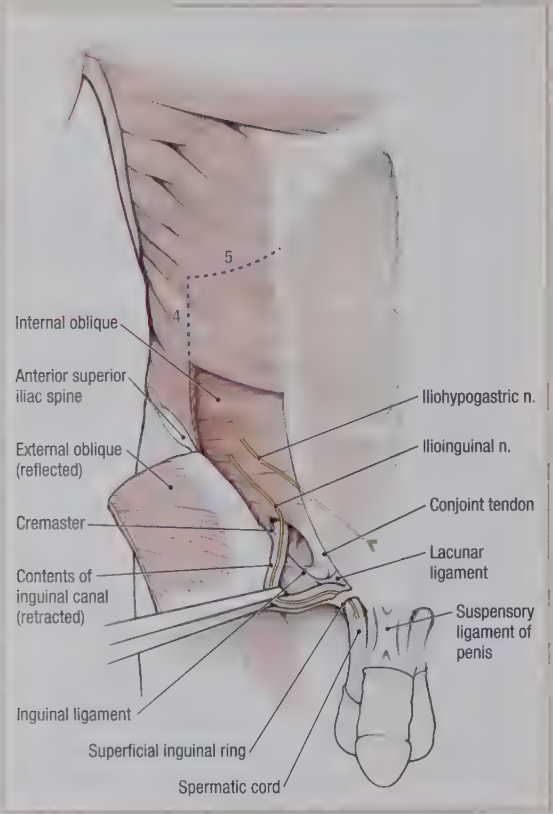

5
4
Internal oblique
Anterior superior iliac spine
External oblique (reflected)
Cremaster
Contents of inguinal canal (retracted)
Inguinal ligament
Superficial inguinal ring
Spermatic cord
Iliohypogastric n.
Ilioinguinal n.
Conjoint tendon
Lacunar ligament
Suspensory ligament of penis

FIGURE 4.9 ● Exposed inguinal canal and internal oblique. Anterior view.

6. Make a vertical cut through the external oblique aponeurosis just lateral to the semilunar line. Continue the cut inferiorly toward the superficial inguinal ring but do not connect the cut through the superficial ring perimeter (**Cut 3**).
7. Refer to FIGURE 4.9.
8. Reflect the flap of external oblique muscle inferiorly, using the inguinal ligament as a hinge to reveal the inguinal portion of the **internal oblique muscle**.
9. Examine the exposed upper portion of the internal oblique muscle fibers and observe that they are arranged perpendicularly to the external oblique muscle fibers and course from superomedial to inferolateral.
10. Examine the exposed lower portion of the internal oblique muscle and observe that the fibers form part of the anterior wall of the inguinal canal laterally.
11. Continue to follow the fibers of the internal oblique and observe that from the lateral half of the inguinal ligament the fibers arch over the spermatic cord (round ligament) to join with the aponeurosis of the transversus abdominis muscle forming the conjoint tendon. *Note that the arching fibers of the internal oblique muscle form parts of the anterior wall laterally, the roof centrally, and the posterior wall medially of the inguinal canal.*
12. Review the attachments and actions of the internal oblique muscle (see **TABLE 4.1**).
13. Identify the **cremaster muscle and fascia**. The cremaster is a small bundle of muscle fibers connecting from the internal oblique muscle to the spermatic cord in the male, or the round ligament of the uterus in the female.
14. Identify the **ilioinguinal nerve** coursing in the intermuscular plane between the external oblique and the internal oblique muscles within the inguinal canal.
15. Observe that the ilioinguinal nerve runs parallel and inferior to the **iliohypogastric nerve** and can be differentiated from as it emerges through the superficial inguinal ring.
16. Using the lateral vertical cut through the external oblique muscle as a guide, continue to cut through the external oblique muscle superiorly toward the costal margin (**Cut 4**). *Note that the easiest point of separation of the anterolateral abdominal wall muscles is laterally near the midaxillary line where the muscles are thickest.*
17. Make an incision through the external oblique muscle about 2 cm superior to the inferior edge of the costal margin and cut medially, keeping the cut parallel to its curvature (**Cut 5**). Continue the cut medially through the muscle fibers stopping at the point where the muscle becomes aponeurotic.
18. Refer to FIGURE 4.10.

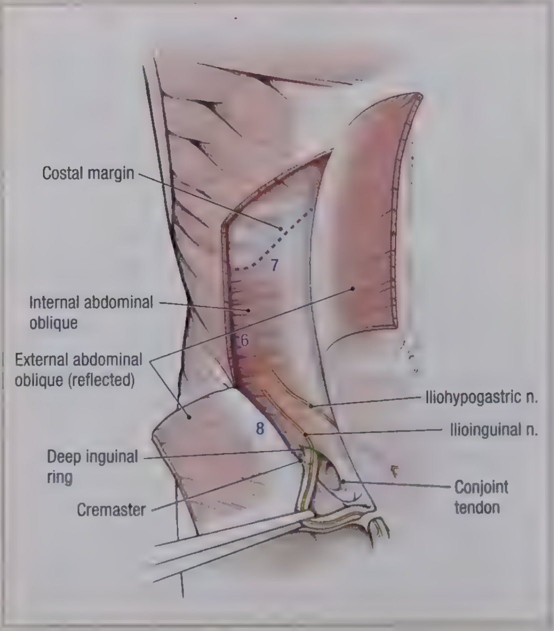
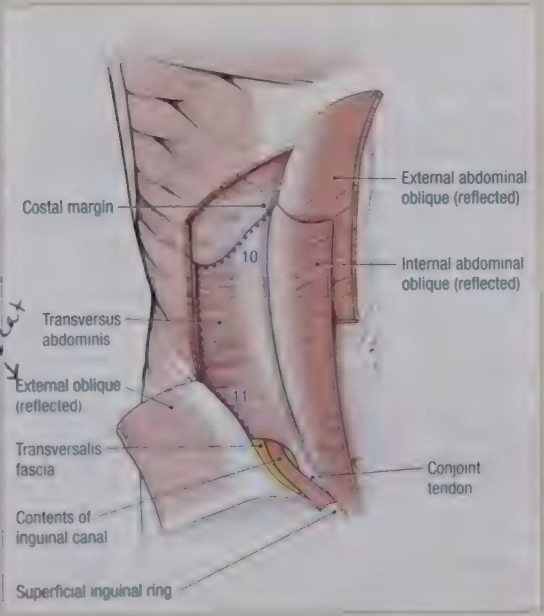

Costal margin
7
Internal abdominal oblique
6
External abdominal oblique (reflected)
8
Deep inguinal ring
Cremaster
Iliohypogastric n.
Ilioinguinal n.
Conjoint tendon

FIGURE 4.10 ● Reflection of internal oblique. Anterior view.

19. Grasp the free edge of the external oblique muscle and use your fingers to separate it from the internal oblique muscle to reflect the superior portion of the muscle medially.
20. Follow the ilioinguinal nerve proximally to find where it pierces the internal oblique muscle and follow it into the plane of separation between the internal oblique muscle and the transversus abdominis muscles.
21. Gently push a probe through the opening where the ilioinguinal nerve pierces the internal oblique to increase the separation of the muscular layers at this location.
22. Make a vertical incision through the internal oblique muscle following the path of the lateral cut through the external oblique muscle (**Cut 6**), making an effort to spare the ilioinguinal and iliohypogastric nerves.
23. Near the ASIS, use your fingers to separate the internal oblique muscle from the underlying transversus abdominis muscle. *Note that the transversus abdominis muscle is difficult to separate from the internal oblique muscle medially because their tendons are fused to form the conjoint tendon near their distal attachments.*
24. Cut through the internal oblique muscle along the costal margin continuing its separation from the underlying transversus abdominis (**Cut 7**).
25. Cut through the internal oblique about 2 cm superior to the inguinal ligament sparing the ilioinguinal nerve continuing its separation from the underlying transversus abdominis and reflect the muscle medially (**Cut 8**).


Costal margin
External abdominal oblique (reflected)
10
Internal abdominal oblique (reflected)
Transversus abdominis
External oblique (reflected)
11
Transversalis fascia
Conjoint tendon
Contents of inguinal canal
Superficial inguinal ring

reflect UNI lat

FIGURE 4.11 ■ Reflection of transversus abdominis. Anterior view.

## Transversus Abdominis Muscle

ATLAS 4.8B, 4.9C; VIDEO 4.2.3

1. Refer to FIGURE 4.11.
2. Deep to the reflected internal oblique muscle, identify the **transversus abdominis**.
3. Examine the exposed upper portion of the transversus abdominis muscle and observe that it has predominantly horizontally oriented fibers.
4. Observe that the arching fibers of the inferior part of the transversus abdominis muscle form part of the roof of the inguinal canal, and its aponeurotic insertion forms part of the posterior wall as is true of the internal oblique muscle.
5. Identify the **transversalis fascia** inferior and deep to the arching fibers of the internal oblique and transversus abdominis muscles.
6. Review the attachments and actions of the transversus abdominis muscle (see **TABLE 4.1**).

## CLINICAL CORRELATION

### Inguinal Hernias

ATLAS 4.18

The inguinal canal is a weak area of the anterior abdominal wall through which abdominal viscera may protrude as an inguinal hernia. An inguinal hernia is classified according to its position relative to the inferior epigastric vessels as shown in FIGURE B4.1. An indirect inguinal hernia exits the abdominal cavity through the deep inguinal ring lateral to the inferior epigastric vessels and follows the inguinal canal (an indirect course through the abdominal wall). In contrast, a direct inguinal hernia exits the abdominal cavity medial to the inferior epigastric vessels through Hesselbach's (inguinal) triangle and follows a relatively direct course through the abdominal wall.

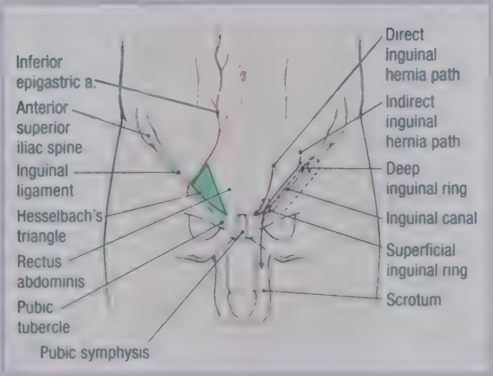

Inferior epigastric a.
Anterior superior iliac spine
Inguinal ligament
Hesselbach's triangle
Rectus abdominis
Pubic tubercle
Pubic symphysis
Direct inguinal hernia path
Indirect inguinal hernia path
Deep inguinal ring
Inguinal canal
Superficial inguinal ring
Scrotum

FIGURE B4.1 ■ Anatomical pathways and relationships of inguinal hernias. Anterior view.

7. Carefully incise the transversus abdominis along the same vertical line as used to cut the external and internal obliques (**Cut 9**) and use a probe or your finger to separate the underlying transversalis fascia and parietal peritoneum from the deep surface of the transversus abdominis muscle. Take care to not pierce the peritoneum and enter the abdominal cavity or cut the thoracoabdominal nerves in the region.
8. Cut through the transversus abdominis muscle along the costal margin continuing its separation from the underlying transversalis fascia (**Cut 10**).
9. Cut through the transversus abdominis about 2 cm superior to the inguinal ligament sparing the ilioinguinal nerve continuing its separation from the underlying transversalis fascia and reflect the muscle medially (**Cut 11**).

## Rectus Abdominis Muscle

ATLAS 4.8A, 4.9D; VIDEO 4.2.4

***Dissection Note:*** Perform the following dissection sequence on only one side.

1. Refer to FIGURE 4.12.
2. On the anterior abdominal wall, identify the **rectus sheath** formed by the aponeuroses of the three pairs of anterolateral abdominal wall muscles (external oblique, internal oblique, and transversus abdominis) as they fuse toward their medial attachment at the **linea alba** around the rectus abdominis muscle.
3. Observe that in the upper three-fourths of the abdomen, the aponeuroses from the external oblique and the anterior lamina of the internal oblique form the **anterior rectus sheath** and that the posterior lamina of the internal oblique and the transversus abdominis form the **posterior rectus sheath**.
4. Observe that halfway between the umbilicus and the pubic symphysis, all layers of the lateral muscle aponeuroses course anterior to the rectus abdominis muscle as the anterior rectus sheath and that there is no longer a posterior rectus sheath below this level.
5. Make a transverse cut through the anterior rectus sheath on the right side beginning at the semilunar line laterally and ending approximately 2.5 cm lateral to the umbilicus. Use a probe to lift the free edge of the rectus sheath as you cut, ensuring you do not cut through the muscle of the underlying **rectus abdominis** (**Cut 1**).
6. Make a vertical incision through the rectus sheath extending in a superior direction along the medial border of the rectus abdominis muscle. Cut superiorly to the costal margin keeping about 2.5 cm from the **linea alba** (**Cut 2**).
7. Extend the vertical cut inferiorly along the medial border of the rectus abdominis muscle to the level of the pubic crest (**Cut 3**) taking care to not disturb the linea alba.
8. Refer to FIGURE 4.13.

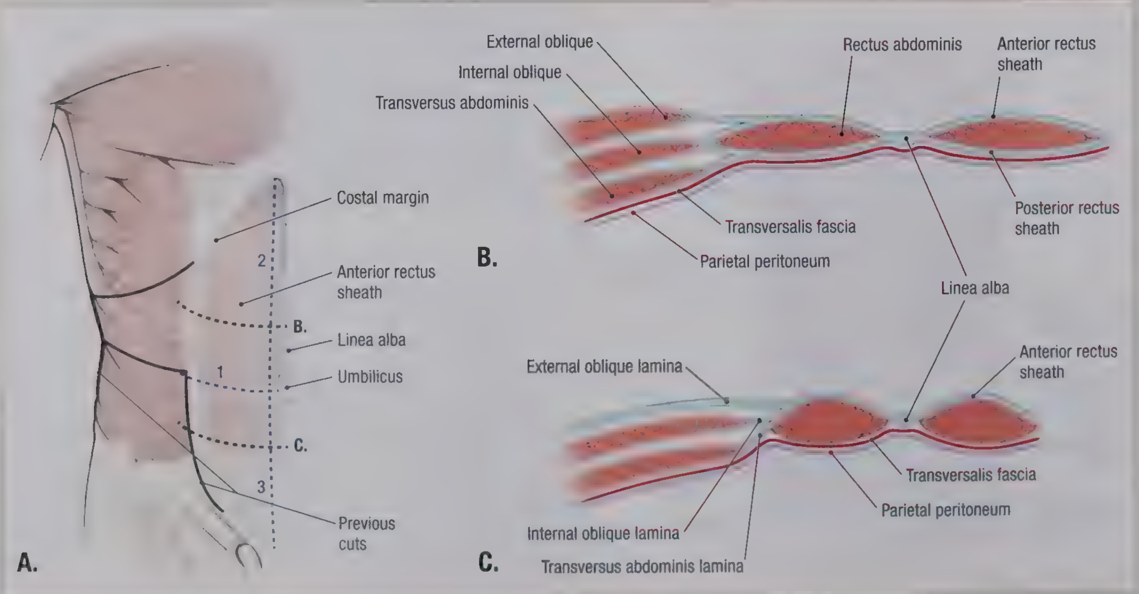

External oblique
Internal oblique
Transversus abdominis
Rectus abdominis
Anterior rectus sheath
Costal margin
Posterior rectus sheath
Transversalis fascia
2
Anterior rectus sheath
B.
Parietal peritoneum
B.
Linea alba
Linea alba
1
Umbilicus
External oblique lamina
Anterior rectus sheath
C.
3
Transversalis fascia
Parietal peritoneum
Previous cuts
Internal oblique lamina
A.
C.
Transversus abdominis lamina

FIGURE 4.12 • A. Opening of the anterior rectus sheath. Anterior view. Axial section through anterior abdominal wall superior to arcuate line (B) and inferior to arcuate line (C). Inferior views.

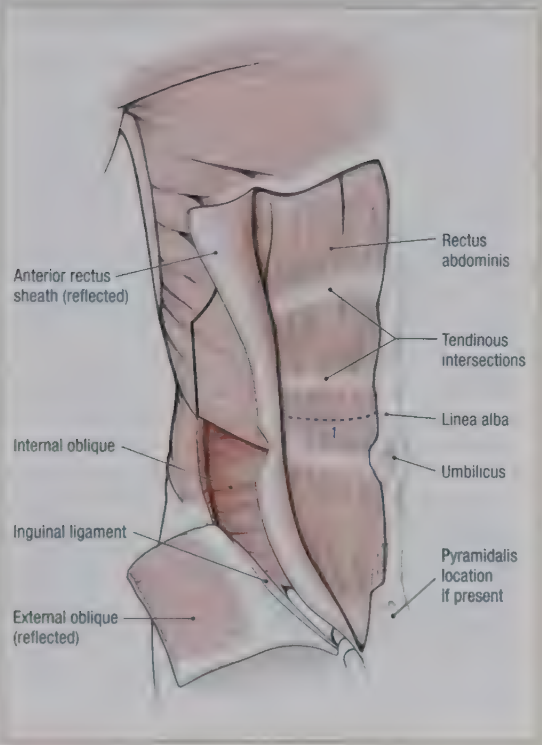

Anterior rectus sheath (reflected)
Rectus abdominis
Tendinous intersections
Linea alba
1
Internal oblique
Umbilicus
Inguinal ligament
Pyramidalis location if present
External oblique (reflected)

FIGURE 4.13 ● Rectus abdominis muscle. Anterior view.

9. Observe that the anterior wall of the rectus sheath is firmly attached to the anterior surface of the rectus abdominis muscle by several **tendinous intersections**.
10. Separate the anterior rectus sheath from the anterior surface of the rectus abdominis muscle between the tendinous intersections.
11. Carefully detach the tendinous intersections from the anterior rectus sheath, by keeping your cutting instrument along the anterior surface of the rectus abdominis muscle, and reflect the rectus sheath laterally.
12. To increase visibility of the rectus abdominis muscle, additional cuts may be made through the anterior rectus sheath both superiorly and inferiorly to allow for further reflection of the sheath.
13. Observe that the subdivisions of the **rectus abdominis muscle** by the tendinous intersections are responsible for the appearance of the "six pack."
14. Review the attachments and actions of the rectus abdominis muscle (see **TABLE 4.1**).
15. Anterior to the inferior aspect of the rectus abdominis muscle, look for the **pyramidalis muscle**. *Note that the pyramidalis muscle is frequently absent, although when present, it attaches to the anterior surface of the pubis and the linea alba.*

## Epigastric Vessels and Deep Inguinal Ring

ATLAS 4.8B, 4.16A; VIDEO 4.2.5

1. Refer to FIGURE 4.13.
2. Use blunt dissection to mobilize the medial border of the rectus abdominis muscle.
3. Near the level of the umbilicus, transect the rectus abdominis muscle on one side (**Cut 1**).
4. Refer to FIGURE 4.14.
5. Along the lateral side of the rectus abdominis muscle, observe that the branches of six nerves (T7–T12) enter the rectus sheath and penetrate the deep surface of the rectus abdominis muscle. The distal parts of the nerves then emerge from the sheath as **anterior cutaneous branches**.
6. Reflect the two halves of the cut rectus abdominis superiorly and inferiorly. If the cutaneous nerves prevent full reflection of the rectus abdominis muscle, cut them where they enter the deep surface of the muscle.
7. On the posterior surface of the rectus abdominis muscle superiorly, identify the **superior epigastric artery** and accompanying veins.
8. On the posterior surface of the rectus abdominis muscle inferiorly, identify the much larger **inferior epigastric artery** and accompanying veins.

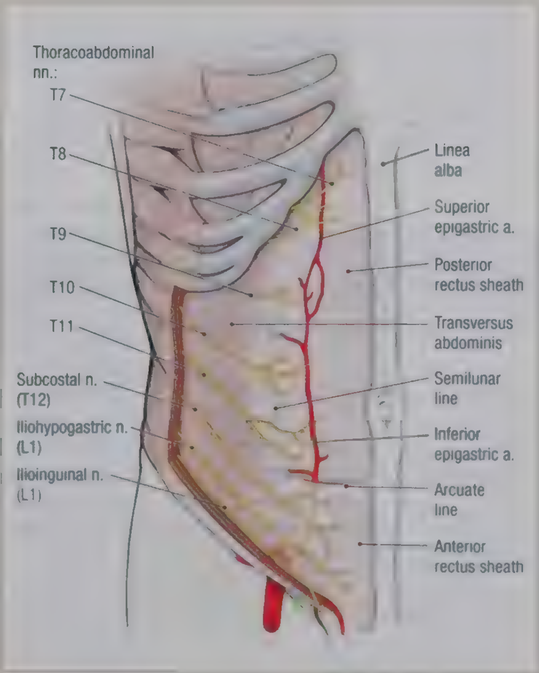

Thoracoabdominal nn.:
T7
T8
T9
T10
T11
Subcostal n. (T12)
Iliohypogastric n. (L1)
Ilioinguinal n. (L1)
Linea alba
Superior epigastric a.
Posterior rectus sheath
Transversus abdominis
Semilunar line
Inferior epigastric a.
Arcuate line
Anterior rectus sheath

FIGURE 4.14 ● Posterior rectus sheath. Anterior view.

**CLINICAL CORRELATION**

### Epigastric Artery Anastomoses

ATLAS 4.5

The superior epigastric vessels anastomose with the inferior epigastric vessels within the rectus sheath. If the inferior vena cava becomes obstructed, the anastomosis between the inferior epigastric and superior epigastric veins provides a collateral venous channel that drains into the superior vena cava. If the aorta is occluded, collateral arterial circulation to the lower part of the body occurs through the superior and inferior epigastric arteries.

9. Examine the posterior wall of the rectus sheath and identify the **arcuate line** midway between the pubic symphysis and the umbilicus.
10. Observe that the inferior epigastric vessels enter the rectus sheath at the level of the arcuate line. *Note that the arcuate line is the inferior limit of the posterior wall of the rectus sheath and may be indistinct.*
11. Inferior to the arcuate line, identify the thin, fibrous transversalis fascia. *Note that the transversalis fascia is reinforced on its deep surface by the parietal peritoneum lining the abdominal cavity.*
12. Retract the spermatic cord (or round ligament of the uterus) inferiorly.
13. Use a probe to lift the arching fibers of the internal oblique and transversus abdominis muscles and observe the **inferior epigastric vessels** through the transversalis fascia. *Note that the inferior epigastric vessels are located within the layer of extraperitoneal fascia.*
14. Observe that the deep inguinal ring is lateral to the inferior epigastric vessels and is identified by the presence of the ductus deferens (or round ligament of the uterus) passing through this area.
15. Use a probe to verify that the anterior wall of the inguinal canal is the aponeurosis of the external oblique muscle along the length of the canal and the internal oblique muscle laterally and that the posterior wall is the transversalis fascia laterally and conjoint tendon medially.
16. Observe that the inferior wall (floor) of the inguinal canal is the inguinal and lacunar ligaments and that the superior wall (roof) is the transversalis fascia laterally, the arching fibers of the internal oblique centrally, and the transversus abdominis muscle medially.

## Dissection Follow-up

1. Review the attachments and action of each muscle in **TABLE 4.1**.
2. Review the structures that form the nine layers of the abdominal wall.
3. Use the dissected specimen to review, compare, and contrast the rectus sheath just superior to the level of the umbilicus and just superior to the pubic symphysis.
4. Review the blood and nerve supply to the anterior abdominal wall.
5. Replace the muscles of the anterior abdominal wall in their correct anatomical positions.
6. Familiarize yourself with the orientation and location of the inguinal canal.

**TABLE 4.1 | Muscles of the Anterolateral Abdominal Wall**

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| External oblique | External surfaces of ribs 5–12 | Linea alba, pubic crest and tubercle, and anterior half of the iliac crest | Compresses and supports abdominal viscera; flexes and rotates the trunk | Thoracoabdominal nn. T7–T11 and subcostal n. |
| Internal oblique | Thoracolumbar fascia, iliac crest, and lateral half of inguinal ligament | Inferior borders of ribs 10–12, linea alba, pubic crest, and pecten pubis via conjoint tendon | | Thoracoabdominal nn. T7–T11, subcostal n., and L1 |
| Transversus abdominis | Internal surfaces of costal cartilages 7–12, thoracolumbar fascia, and iliac crest | Linea alba with internal oblique, pubic crest, and pecten pubis via conjoint tendon | | |
| Rectus abdominis | Xiphoid process, costal cartilages 5–7 | Pubic symphysis and pubic crest | Flexes trunk, assists in pelvic tilt, and compresses abdominal viscera | Thoracoabdominal nn. T7–T11 and subcostal n. |

Abbreviations: n., nerve; nn., nerves.

# REFLECTION OF THE ABDOMINAL WALL

## Dissection Overview

As the abdominal cavity is commonly described in both quadrant and regional subdivisions, two methods of abdominal wall dissection will be described, and either method may be followed depending on the needs of the course. The first dissection sequence subdivides the anterior abdominal wall into quadrants. Direct reference to the position of the abdominal organs within the abdominal quadrants will thus be given with the quadrant technique; however, the portions of reflected abdominal wall may become a hindrance later in the dissection protocol.

The second dissection sequence involves reflecting the entire anterior abdominal wall in one large piece. Reflecting the entire wall maintains the anatomical relations of the structures coursing along the inner aspect of the anterior abdominal wall inferiorly. The entire anterior abdominal wall can be repositioned for reviewing either the quadrant or the regional approach to subdividing the abdominal cavity and contents.

The order of dissection will be as follows: The anterior abdominal wall will be cut and opened in either the abdominal quadrant reflection approach or the abdominal wall reflection approach. The inner surface of the anterior abdominal wall will be studied.

## Dissection Instructions

***Dissection Note:*** Select either the **Abdominal Quadrant Reflection** or **Abdominal Wall Reflection** approach for your study of the anterior abdominal wall and disregard the dissection sequence for the other approach. When you have finished with the selected approach, continue to the **Peritoneum and Peritoneal Cavity** section.

### Abdominal Quadrant Reflections

ATLAS 4.10; VIDEO 4.3.1

***Dissection Note:*** If performing the **Abdominal Wall Reflection**, skip the following instructional sequence.

1. Refer to FIGURE 4.15A.
2. Reflect the halves of the rectus abdominis muscles superiorly and inferiorly.
3. On the left side of the umbilicus, use scissors to create a small hole (2.5 cm) through the posterior wall of the rectus sheath, extraperitoneal fascia, and parietal peritoneum.
4. Insert your finger or a blunt probe through the hole into the abdominal cavity and pull the posterior wall of the rectus sheath and associated extraperitoneal fascia and peritoneum anteriorly to create a space between the anterior abdominal wall and the abdominal viscera.
5. Make a vertical cut through the linea alba to the xiphoid process 1 cm to the left of the midline to preserve the falciform ligament (**Cut 1**).
6. Extend the midline cut inferiorly as far as the pubic symphysis, staying 1 cm to the left of the midline to preserve the median umbilical fold (**Cut 2**).
7. Return the rectus abdominis muscles to their correct anatomical positions.
8. At the level of the umbilicus, place one hand through the vertical cut and raise the abdominal wall creating a space between it and the abdominal contents.
9. Make a horizontal incision through the posterior wall of the rectus sheath, extraperitoneal fascia, and peritoneum in the transumbilical plane (**Cut 3**). The scissors should pass through the previous transverse cut made in the rectus abdominis muscle and the external oblique muscle.
10. Extend the transverse incision laterally through lateral abdominal wall muscles and tissue as far as the midaxillary line.
11. Repeat the transverse cut on the left side of the abdomen (**Cut 4**).
12. Open the flaps of the abdominal wall and identify the **falciform ligament** on the inner surface of the right upper quadrant flap. Observe that the falciform ligament connects the parietal peritoneum on the posterior aspect of the anterior abdominal wall to the visceral peritoneum on the anterior surface of the liver.

### Abdominal Wall Reflection

ATLAS 4.10, 4.22A; VIDEO 4.3.2

***Dissection Note:*** If performing the abdominal quadrant reflection dissection approach, skip ahead to the instructional sequence entitled **Anterior Abdominal Wall**.

1. Refer to FIGURE 4.15B.
2. Reflect the transected portion of the rectus abdominis superiorly on the right side.
3. Cut through the posterior rectus sheath superiorly to free the anterior abdominal wall from the costal margin and xiphoid process (**Cut 5**).
4. Make an incision through the transversalis fascia and parietal peritoneum beginning at the midline around the circumference of the entire cut edge of anterolateral abdominal wall musculature to the right until you reach the iliac crest.
5. On the left, make an incision through anterior rectus sheath following the curve of the costal margin and

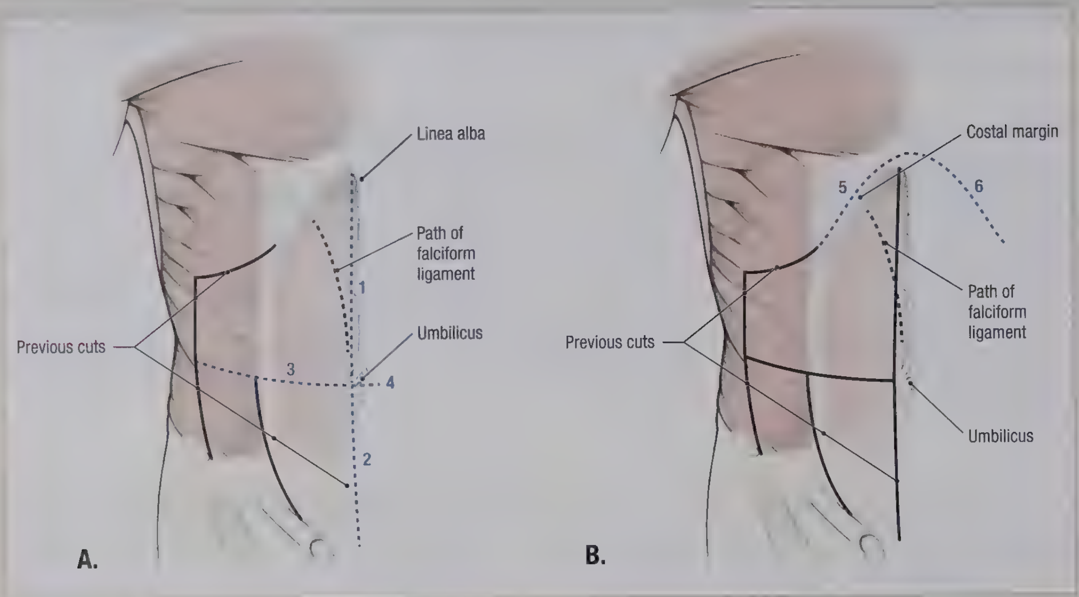


FIGURE 4.15 Opening the anterior abdominal wall using the quadrant approach (**A**) or the reflection approach (**B**). Anterior views.

reflect the sheath to expose the underlying rectus abdominis fibers.

6. Use a probe to elevate the superior portion of the left rectus abdominis muscle along its superior attachment and transect the muscle fibers superior to the curve of the costal margin.
7. Continue the transverse cut laterally through the attached portions of anterolateral abdominal wall muscles following the curve of the costal margin toward the midaxillary line (**Cut 6**). *Note that a portion of this cut was made during the reflection of the abdominal oblique muscles.*
8. Make an incision through the transversalis fascia and parietal peritoneum beginning at the midline around the circumference of the entire cut edge of anterolateral abdominal wall musculature to the left until you reach the iliac crest.
9. Begin reflection of the entire anterolateral abdominal wall in the upper right-hand quadrant of the abdomen.
10. Cut through the falciform ligament attaching the anterior surface of the liver to the posterior (inner) surface of the anterior abdominal wall. Make the cut as close to the abdominal wall as possible.
11. Reflect the entire anterior abdominal wall inferiorly using the distal attachments of the muscles to the suprapubic region as a hinge.
12. To increase mobility of the flap of abdominal wall, it may be helpful to make short lateral incisions just above the inguinal ligament to the lateral umbilical folds to free the musculature and reflected wall.

## Anterior Abdominal Wall

ATLAS 4.21; VIDEO 4.3.3

1. Refer to FIGURE 4.16.
2. On the inner surface of the lower abdominal wall, identify three folds beginning with the **median umbilical fold**, which lies in the midline inferior to the umbilicus. *Note that the median umbilical fold contains the urachus, the remnant of the allantois from embryological development.*
3. Identify the **medial umbilical fold** located lateral to the median umbilical fold, which angles inferolaterally away from the median umbilical fold. *Note that the medial umbilical fold contains the remnant of the obliterated umbilical artery from embryological development.*
4. Identify the **lateral umbilical fold** located lateral to the medial umbilical fold, which overlies the inferior epigastric artery and vein. *Note that the lateral fold contains the only functional contents of the umbilical folds.*
5. Lateral to the lateral umbilical fold, observe a small depression in the peritoneum marking the location of the **deep inguinal ring** in the transversalis fascia. *Note that in the male, this depression is more readily visible due to the presence of the testicular vessels and vas deferens passing through the deep inguinal ring to the inguinal canal.*

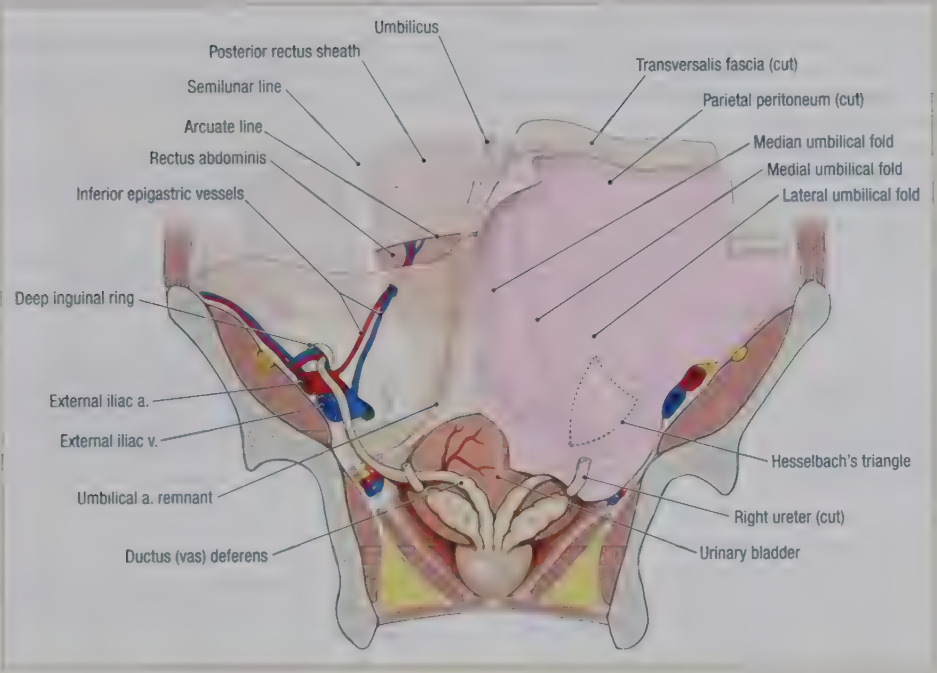

Umbilicus
Posterior rectus sheath
Semilunar line
Arcuate line
Rectus abdominis
Inferior epigastric vessels
Deep inguinal ring
External iliac a.
External iliac v.
Umbilical a. remnant
Ductus (vas) deferens
Transversalis fascia (cut)
Parietal peritoneum (cut)
Median umbilical fold
Medial umbilical fold
Lateral umbilical fold
Hesselbach's triangle
Right ureter (cut)
Urinary bladder

FIGURE 4.16 ● Anterior abdominal wall. Posterior view.

6. Observe that the inferior abdominal wall medial to the inferior epigastric vessels is less supported internally by the aponeuroses thus creating a natural weak point in the posterior wall of the inguinal canal known as **Hesselbach's (inguinal) triangle**.
7. Hesselbach's triangle is bound laterally by the inferior epigastric vessels, medially by the lateral edge of the rectus abdominis muscle, and inferiorly by the inguinal ligament. *Note that a direct inguinal hernia will pass through the triangle, whereas an indirect hernia will pass through the deep inguinal ring.*

## Dissection Follow-up

1. Review the location of the falciform ligament.
2. Review the location and contents forming each umbilical fold.
3. Compare the contents entering the deep inguinal ring in both male and female cadaveric specimens.
4. Replace the muscles of the anterior abdominal wall in their correct anatomical positions.

# PERITONEUM AND PERITONEAL CAVITY

## Dissection Overview

All body cavities (thoracic, pericardial, abdominal, and pelvic) are lined by regionally named serous membranes, which secrete a small amount of fluid to lubricate the movements of organs. In the abdominal and pelvic cavities, this bilayer membrane is called the peritoneum. The parietal peritoneum lines the inner surfaces of the abdominal and pelvic walls, and the visceral peritoneum covers the surfaces of the abdominal and pelvic organs. Between the two layers of peritoneum is a potential space called the peritoneal cavity.

During embryological development, some abdominal organs grow away from the posterior abdominal wall and end up suspended by peritoneum within the peritoneal cavity carrying their neurovascular supply with them and are referred to as intraperitoneal (peritoneal) organs. Intraperitoneal organs include the stomach, the first part of the duodenum, the jejunum, the ileum, the cecum and appendix, the transverse colon, the sigmoid colon, the upper one-third of the rectum, the liver, the tail of the pancreas, and the spleen.

Other abdominal organs develop behind the peritoneum and are not suspended in the peritoneal cavity and are called retroperitoneal (extraperitoneal) organs. Retroperitoneal organs include the kidneys, the ureters, the suprarenal glands, and the inferior two-thirds of the rectum. Infraperitoneal refers to organs located inferior to the parietal peritoneum within the pelvic region.

Some parts of the gastrointestinal tract begin as intraperitoneal organs in the embryo but become attached to the abdominal wall later in development and thus are referred to as secondarily retroperitoneal. Examples of secondarily retroperitoneal organs include the duodenum (second through fourth parts); the head, neck, and uncinate process of the pancreas; the ascending colon; and the descending colon.

The order of dissection will be as follows: The abdominal viscera will be identified in situ and localized by abdominal quadrant. The named specializations of the peritoneum will be studied. For a more complete understanding, review the development of the gastrointestinal tract before examining the peritoneal specializations.

## Dissection Instructions

### Abdominal Viscera

ATLAS 4.22, 4.31A; VIDEO 4.4.1

1. Refer to FIGURE 4.17.
2. Reflect the anterior abdominal wall.
3. Inspect the abdominal cavity observing how some organs are suspended within the cavity (intraperitoneal), whereas others lie further posteriorly covered by peritoneum (retroperitoneal).
4. As you perform the inspection, you may encounter adhesions between the abdominal wall and organs or between parts of organs. If adhesions are present, separate them gently with your fingers or carefully cut them with scissors to mobilize the organs. Take care while detaching adhesions to not puncture the intestinal organs.
5. As you examine the organs in the abdominal cavity, particularly those related to the **gastrointestinal tract**, relate the organs to the four abdominal quadrants.

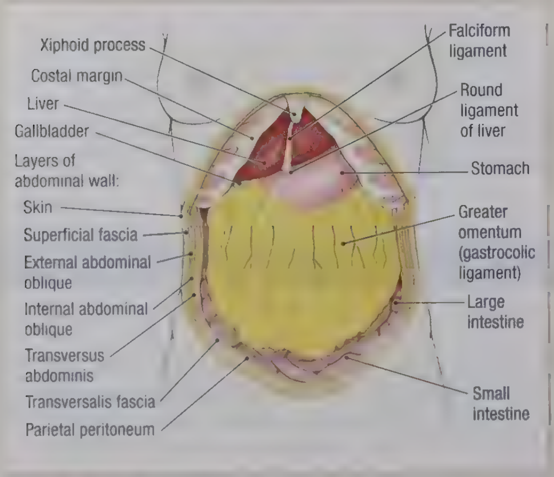


FIGURE 4.17 ■ Abdominal cavity contents in situ. Anterior view.

6. Identify the **liver** in the right upper quadrant extending across the midline into the left upper quadrant. The liver lies against the inferior surface of the diaphragm to which it is attached by ligaments made of peritoneum. The attachment of the falciform ligament from the anterior abdominal wall divides the liver into **right** and **left lobes**.
7. Identify the **gallbladder** in the right upper quadrant where it extends below the inferior border of the liver. *Note that commonly the gallbladder is found at the tip of the right ninth costal cartilage in the midclavicular line.*
8. Identify the **stomach** in the left upper quadrant. Observe that the stomach lies deep to the liver, which partially covers its anterior surface. Verify that the stomach is continuous with the esophagus proximally and the duodenum distally.
9. Find the **spleen** in the left upper quadrant posterior to the stomach. Reach around the left side of the stomach with your right hand and cup the spleen in your hand.
10. Identify the **greater omentum** attached to the greater curvature of the stomach.
11. Refer to FIGURE 4.18.
12. Reflect the greater omentum superiorly over the costal margin and identify the **small intestine**.
13. The small intestine has three parts and begins at the pyloric end of the stomach with the **duodenum**, followed by the **jejunum**, and ending as the **ileum**. *Note that the duodenum lies posterior to the other parts of the gastrointestinal tract and will be dissected and studied with the pancreas.*
14. The **jejunum** and **ileum** extend from the left upper quadrant to the right lower quadrant, but due to their length and mobility, they occupy all four abdominal quadrants. Beginning in the left upper quadrant, pass the jejunum and ileum between your hands and appreciate their length, position, comparative thickness, and termination.
15. Identify the **large intestine** beginning in the right lower quadrant at the ileocecal junction where it meets the ileum. Use your hands to trace the large

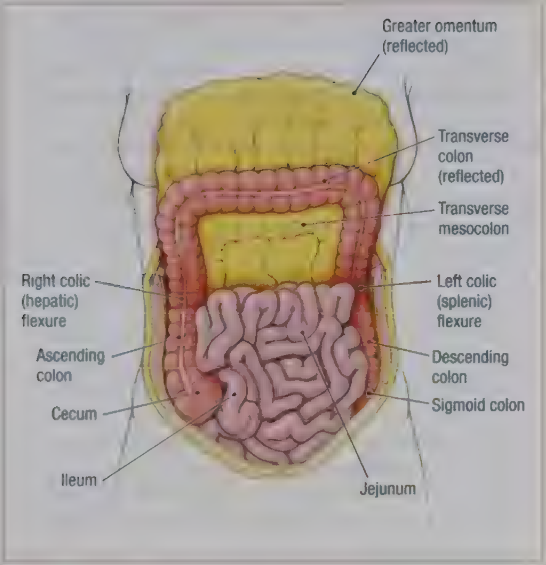

Greater omentum (reflected)
Transverse colon (reflected)
Transverse mesocolon
Right colic (hepatic) flexure
Left colic (splenic) flexure
Ascending colon
Descending colon
Cecum
Sigmoid colon
Ileum
Jejunum

FIGURE 4.18 ● Abdominal cavity contents with reflected transverse colon and greater omentum. Anterior view.

intestine from the right lower quadrant to the left lower quadrant noting the position (quadrant) and mobility of each of its six parts.

16. Identify the **cecum**, the first of six portions of the large intestine, in the right lower quadrant. Observe, on the inferior end of the cecum, the "worm-like" outgrowth of the **vermiform appendix**. *Note that the appendix has a variety of orientations and may or may not be present because it commonly becomes inflamed and is removed surgically.*
17. Follow the cecum superiorly and identify the **ascending colon**, which extends from the right lower quadrant to the right upper quadrant, where it ends at the **right colic (hepatic) flexure**.
18. At the hepatic flexure, the large intestine changes direction and courses horizontally as the **transverse colon**, which extends from the right upper quadrant to the left upper quadrant ending at the **left colic (splenic) flexure**.
19. At the splenic flexure, the large intestine curves inferiorly as the **descending colon**, which extends from the left upper quadrant to the left lower quadrant.
20. The **sigmoid colon** is located in the left lower quadrant and is the portion of the large intestine coursing from the abdominal cavity into the pelvic cavity, ending at the level of the third sacral vertebra.
21. The last portion of the large intestine, the **rectum**, is located partly in the abdomen and partly in the pelvis. The superior one-third of the rectum will be dissected with the abdominal viscera. The inferior two-thirds will be dissected with the pelvic viscera.

## Reflection of the Diaphragm

ATLAS 4.22A, VIDEO 4.4.2

***Dissection Note:*** Depending on the cadaver, some of the structures within the abdominal cavity may or may not be readily visible. If the thorax has previously been dissected, but visibility of the upper abdominal cavity remains limited and mobility of the contents is difficult, use the following dissection steps to increase visibility of the abdominal contents. If organ visibility is clear, proceed to the **Peritoneum** sequence.

1. On the left side only, use bone cutters to detach the costal cartilages of ribs 6 and 7 from the xiphisternal junction and lateral border of the sternum.
2. Working through the opening just created, use your hands to elevate the left side of the costal cartilage and use scissors to detach the diaphragm from its anterior attachment on the posterior surface of the costal cartilages.
3. Continue to reflect the left portion of the costal cartilage laterally toward the midaxillary line leaving the lateral aspect connected to act as a hinge.
4. Repeat steps 2 and 3 on the right side and reflect the right costal cartilage laterally.
5. Beginning near the midaxillary line, use scissors to make an incision through the muscular portions of the left and right hemidiaphragms arching medially toward the central tendon of the diaphragm while sparing the central tendon and phrenic nerves.
6. Reflect the anterior aspect of the diaphragm superiorly into the thoracic cavity using the ligamentous attachments to the liver as a hinge.

## Peritoneum

ATLAS 4.22B, 4.23, 4.25A; VIDEO 4.4.3

1. Refer to FIGURE 4.19.
2. Identify the **visceral peritoneum** on the surface of the stomach, small intestine, large intestine, or liver and observe that it is smooth and slippery.
3. Identify the **parietal peritoneum** on the inner surface of the abdominal wall. Observe that the parietal peritoneum is a continuous layer with the visceral peritoneum but changes names due to location.
4. Identify the **greater omentum** and observe that it attaches to the greater curvature of the stomach. The greater omentum extends out into the abdominal cavity and then doubles back on itself and attaches to the transverse colon. *Note that the greater omentum typically lies between the intestines and the anterior abdominal wall but may shift in location or become partially fused to surrounding structures.*
5. Spread out the apron-like structure of the greater omentum and identify the dominant portion, the **gastrocolic ligament**, which attaches from the greater curvature of the stomach to the inferior

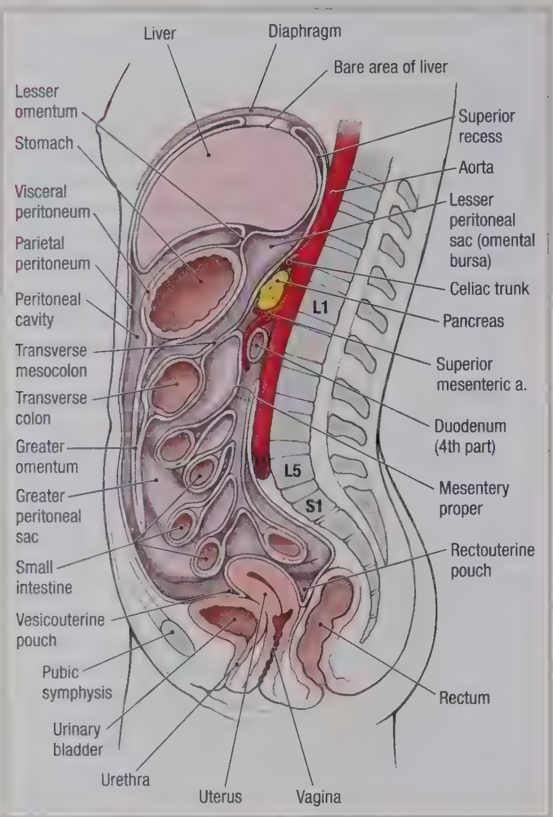

Liver
Diaphragm
Bare area of liver
Lesser omentum
Stomach
Visceral peritoneum
Parietal peritoneum
Peritoneal cavity
Transverse mesocolon
Transverse colon
Greater omentum
Greater peritoneal sac
Small intestine
Vesicouterine pouch
Pubic symphysis
Urinary bladder
Urethra
Uterus
Vagina
Superior recess
Aorta
Lesser peritoneal sac (omental bursa)
Celiac trunk
Pancreas
Superior mesenteric a.
Duodenum (4th part)
Mesentery proper
Rectouterine pouch
Rectum
L1
L5
S1

FIGURE 4.19 ● Midsagittal section of female peritoneal cavity. Lateral view.

aspect of the diaphragm. *Note that the remaining portions of the greater omentum, the gastrosplenic and gastrophrenic ligaments, will be more visible later.*

6. Elevate the inferior border of the liver and identify the **lesser omentum** attaching from the inferior surface of the liver to the lesser curvature of the stomach and first part of the duodenum. *Note that the subdivision of the lesser omentum will be studied with the visceral surface of the liver.*
7. Reflect the greater omentum superiorly over the costal margin and identify the **transverse mesocolon**. The transverse mesocolon attaches from the transverse colon to the anterior surface of the duodenum and pancreas along the posterior abdominal wall. At the left end of the transverse mesocolon is the **phrenicocolic ligament**, which attaches the left colic flexure to the diaphragm.
8. Identify the **mesentery proper** suspending the jejunum and ileum from the posterior abdominal wall. The root of the mesentery attaches to the posterior abdominal wall along an oblique line from the left upper quadrant to the right lower quadrant.
9. Observe that the parietal peritoneum lines the posterior abdominal wall superior to the oblique attachment of the mesentery proper to fill the **right inframesocolic compartment** in the region medial to the ascending colon.
10. On the lateral side of the ascending colon, identify the **right paracolic gutter**. Observe that the paracolic gutter is the point of reflection of peritoneum from the lateral wall of the abdominal cavity to the surface of the organ.
11. Elevate the small intestine with the mesentery proper and observe that the parietal peritoneum lines the posterior abdominal wall inferior to the oblique attachment of the mesentery proper to fill the **left inframesocolic compartment** in the region medial to the descending colon.
12. On the lateral side of the descending colon, identify the **left paracolic gutter**.
13. Identify the **mesoappendix**, which attaches the appendix to the distal ileum and cecum and contains the appendicular artery.
14. Identify the **sigmoid mesocolon** in the lower left quadrant, which suspends the sigmoid colon from the posterior abdominal wall.
15. Refer to FIGURE 4.20.
16. On the anterior surface of the liver, identify the **falciform ligament**. The falciform ligament passes from the parietal peritoneum on the anterior abdominal wall to the visceral peritoneum on the surface of the liver.
17. Identify the **round ligament of the liver (ligamentum teres hepatis)** in the inferior edge of the falciform ligament. *Note that the round ligament of the liver is the remnant of the left umbilical vein from fetal development.*

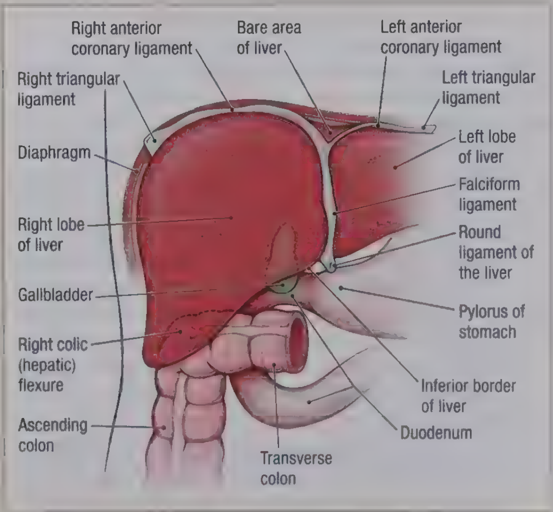

Right anterior coronary ligament
Bare area of liver
Left anterior coronary ligament
Right triangular ligament
Left triangular ligament
Diaphragm
Left lobe of liver
Falciform ligament
Right lobe of liver
Round ligament of the liver
Gallbladder
Pylorus of stomach
Right colic (hepatic) flexure
Inferior border of liver
Ascending colon
Duodenum
Transverse colon

FIGURE 4.20 ● Ligaments of the liver. Anterior view.

18. Follow the falciform ligament superiorly and observe that it is continuous with the **coronary ligament** attaching the liver to the inferior aspect of the diaphragm. The coronary ligament bounds the region of the liver known as the **bare area** and can be subdivided into **right** and **left anterior** and right and left posterior portions.
19. The lateral aspects of the coronary ligaments fuse as the **left triangular ligament**, between the left lobe of the liver and the diaphragm, and the **right triangular ligament**, between the right lobe of the liver and the diaphragm.
20. Refer to FIGURE 4.21.
21. The previously identified peritoneal structures are all found in a part of the peritoneal cavity called the **greater peritoneal sac.** Posterior to the stomach and lesser omentum is a smaller part of the peritoneal cavity called the **lesser peritoneal sac (omental bursa).**
22. The **omental foramen (epiploic foramen)** connects the greater and lesser peritoneal sacs and lies posterior to the hepatoduodenal ligament.
23. Study a diagram of the **lesser peritoneal sac** to appreciate that its lowest part, the **inferior recess**, extends inferiorly as far as the greater omentum. *Note that during development, the inferior recess extended between the layers of the greater omentum.*

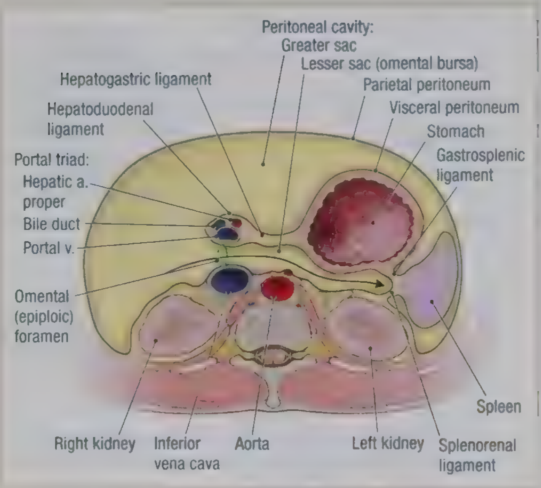


FIGURE 4.21 ● Axial section through abdominal cavity. Inferior view.

24. The highest part of the lesser peritoneal sac, the **superior recess**, extends superiorly between the diaphragm and the caudate lobe of the liver. *Note that the posterior wall of the lesser peritoneal sac is the peritoneum overlying the pancreas.*

## Dissection Follow-up

1. Review all parts of the gastrointestinal tract proximal to distal in order.
2. State the quadrant(s) in which each abdominal organ is typically found.
3. List the intraperitoneal organs and name the specialized peritoneal structures suspending each.
4. Review the locations of the paracolic and mesenteric gutters and discuss how these channels can assist in the spread of infection or disease.
5. Review the list of retroperitoneal and secondarily retroperitoneal organs.
6. Replace the abdominal organs and muscles of the anterior abdominal wall in their correct anatomical positions.

# CELIAC TRUNK, STOMACH, SPLEEN, LIVER, AND GALLBLADDER

## Dissection Overview

During embryonic development, the primitive gut tube subdivides into three distinct components based on location and vascular supply. In the abdominal cavity, the component derived from the embryonic foregut will receive vascular supply from branches of the celiac trunk, the midgut from branches of the superior mesenteric artery, and the hindgut from the inferior mesenteric artery. The stomach, spleen, liver, and gallbladder all receive blood supply from the celiac trunk and are classified as intraperitoneal structures, and thus will be studied together.

The celiac trunk arises from the anterior surface of the abdominal aorta near its entrance into the abdominal cavity via the aortic hiatus at vertebral level T12. At its origin, the celiac trunk is approximately encircled by the lesser curvature of the stomach. To more accurately locate the origin of the celiac trunk, it is recommended to first locate more distal arterial branches and follow them toward their source of origination.

The order of dissection will be as follows: The surface features of the stomach will be studied. The vessels and ducts in the hepatoduodenal ligament will be dissected, and the branches of the celiac trunk that supply the stomach, spleen, liver, and gallbladder will be dissected. The remainder of the field of supply of the celiac trunk (to the duodenum and pancreas) will be dissected later. The hepatic portal vein will be studied. The surface features of the spleen, liver, and gallbladder will be studied.

# Dissection Instructions

## Stomach and Visceral Surface of the Liver

ATLAS 4.28, 4.29, 4.32, 4.51; VIDEO 4.5.1

1. Refer to FIGURE 4.22.
2. With the gastrocolic portion of the greater omentum in its correct anatomical position, identify the **greater curvature** of the stomach on the left lateral margin of the **body of the stomach**.
3. Observe that the body of the stomach is inferior to the rounded superior protrusion of the **fundus**.
4. Observe that the fundus of the stomach connects to the inferior aspect of the diaphragm by the **gastrophrenic** portion (ligament) of the greater omentum and that the body of the stomach along the greater curvature also connects to the spleen by the **gastrosplenic (gastrolienal)** portion (ligament) of the greater omentum.
5. Identify the **cardial (cardiac) notch**, which delineates the fundus from the **cardia** of the stomach. Observe that the cardia contains the inlet of the stomach connecting to the esophagus.
6. Identify the **lesser curvature** of the stomach on the right margin and observe the change of direction of the curvature at the **angular incisure (notch)**, where the body of the stomach transitions to the **pyloric part**.
7. Within the pyloric region of the stomach, palpate the **pyloric sphincter**, the circular muscle responsible for controlling the passage of food from the stomach to the duodenum.
8. Refer to FIGURE 4.23.
9. On the anterior surface of the liver, identify the **right lobe** and **left lobe** on either side of the falciform ligament.

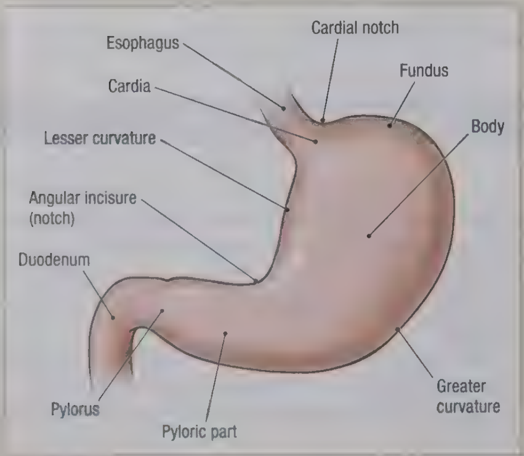

Esophagus
Cardial notch
Fundus
Cardia
Body
Lesser curvature
Angular incisure (notch)
Duodenum
Pylorus
Pyloric part
Greater curvature

FIGURE 4.22 ● Parts of the stomach. Anterior view.

10. Follow either lobe superiorly to identify the **diaphragmatic surface** of the liver and inferiorly to identify the **inferior border** of the liver on the free edge of the anterior surface.
11. Use your hand to raise the inferior border of the liver and identify the **visceral surface of the liver**. The visceral surface is in contact with the gallbladder and the peritoneum covering the stomach, duodenum, colon, right kidney, and right suprarenal gland.
12. On the visceral surface of the liver, identify the **porta hepatis**, the fissure through which vessels, ducts, lymphatics, and nerves enter and leave the liver.
13. Identify the **gallbladder** along the inferior border of the liver and observe that it is directed posteriorly toward the porta hepatis. *Note that the gallbladder may have been surgically removed; however, the depression marking its location should still be visible on the visceral surface of the liver.*
14. Identify the **lesser omentum** attaching from the lesser curvature of the stomach to the visceral surface of the liver.
15. The points of attachment subdivide the lesser omentum into two portions: the **hepatogastric ligament**, from the liver to the lesser curvature of the stomach, and the **hepatoduodenal ligament**, from the liver to the first part of the duodenum.
16. Insert your finger into the **omental foramen** and review its boundaries beginning with the **anterior boundary** formed by the hepatoduodenal ligament, which contains the **hepatic portal vein**, the **hepatic artery proper**, and the **common bile duct** along with autonomic nerves, and lymphatic vessels.

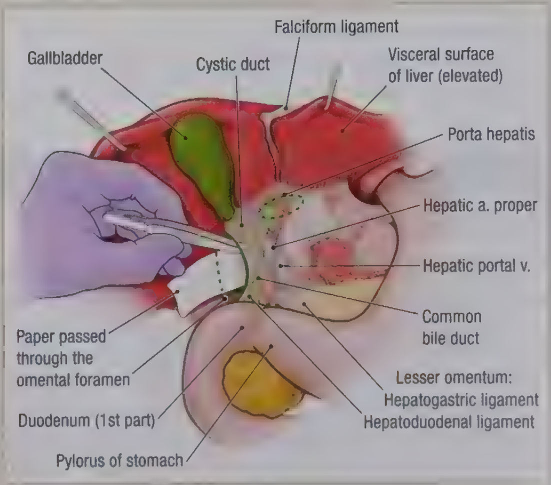

Falciform ligament
Gallbladder
Cystic duct
Visceral surface of liver (elevated)
Porta hepatis
Hepatic a. proper
Hepatic portal v.
Common bile duct
Paper passed through the omental foramen
Lesser omentum:
Hepatogastric ligament
Hepatoduodenal ligament
Duodenum (1st part)
Pylorus of stomach

FIGURE 4.23 ● Lesser omentum and omental foramen. Anterior view.

17. Identify the **posterior boundary** of the omental foramen, which is the parietal peritoneum overlying the **inferior vena cava** and right crus of the diaphragm.
18. Identify the superior boundary of the omental foramen, which is the caudate lobe of the liver, and the inferior boundary, which is the **first part of the duodenum**, both of which are covered with visceral peritoneum.

## Portal Triad

ATLAS 4.29, 4.30; VIDEO 4.5.2

***Dissection Note:*** As you dissect the branches of the celiac trunk, realize that the arteries are named by their region of distribution and not by their point of origin or branching pattern.

1. Refer to FIGURE 4.23.
2. Gently elevate the liver and diaphragm superiorly to expose the lesser omentum.
3. To aid dissection, a strip of white paper may be placed into the omental foramen to increase visibility of the surrounding structures.
4. Use blunt dissection to separate the peritoneum of the hepatoduodenal ligament anterior to the vessels and ducts.
5. Within the hepatoduodenal ligament, identify contents of the **portal triad**: the **bile duct** laterally, the **hepatic artery proper** medially, and the **hepatic portal vein** posteriorly.
6. Use blunt dissection to trace the bile duct superiorly and identify the **cystic duct** and the **common hepatic duct**.
7. Follow the common hepatic duct superiorly until it receives its tributaries, the **right hepatic duct** and the **left hepatic duct**, which exit the **porta hepatis**.
8. Return to the hepatoduodenal ligament and clean the **hepatic artery proper** removing the tough "connective tissue" around this vessel. The connective tissue is so tough because it contains an autonomic nerve plexus. Use the scissors technique to remove the autonomic nerve fibers from the artery.
9. Refer to FIGURE 4.24.
10. Follow the hepatic artery proper toward the liver until it branches, into the **left hepatic artery** and the **right hepatic artery** near the porta hepatis.
11. Identify the **cystic artery** arising from the right hepatic artery in the hepatoduodenal ligament and follow it toward the gallbladder.
12. Identify the **right gastric artery** arising from the hepatic artery proper and follow it to the lesser curvature of the stomach.
13. Identify the large **hepatic portal vein** lying posterior to both the hepatic artery proper and the bile duct.

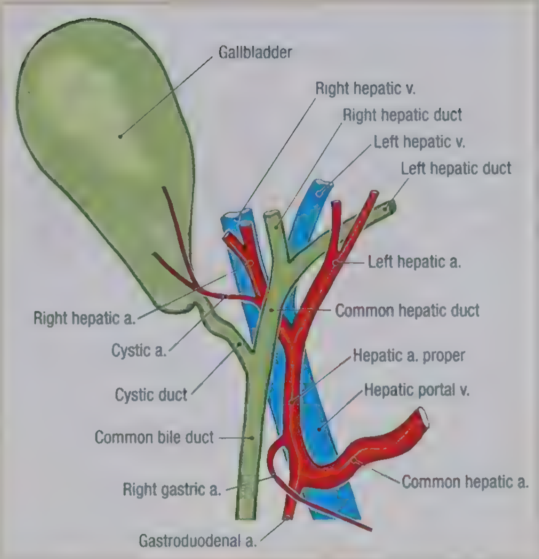


FIGURE 4.24 ● Portal triad in isolation. Anterior view.

14. Follow the hepatic portal vein superiorly and observe that it passes into the porta hepatis where it divides into **right and left portal veins**. *Note that the hepatic portal vein usually receives the left and right gastric veins as tributaries.*
15. Follow the hepatic portal vein inferiorly and observe that it passes posterior to the first part of the duodenum.
16. Identify and remove any visible lymph nodes within the hepatoduodenal ligament. *Note that the lymphatic vessels accompanying the lymph nodes are typically too small to see in embalmed specimens, and no effort should be made to identify them.*

## Celiac Trunk

ATLAS 4.33; VIDEO 4.5.3

***Dissection Note:*** The following dissection descriptions reference a common pattern of branching of the celiac trunk and associated vessels. As mentioned in the clinical correlation, **Anatomical Variation in Cystic Arteries,** variations in the arteries of this region are common.

1. Refer to FIGURE 4.25.
2. Use blunt dissection to gently split the hepatogastric ligament near its attachment to the liver.
3. Follow the hepatic artery proper inferiorly and confirm that it is the continuation of the **common hepatic artery**.
4. Observe that the common hepatic artery gives rise to the **gastroduodenal artery**, which passes posterior to the first part of the duodenum.

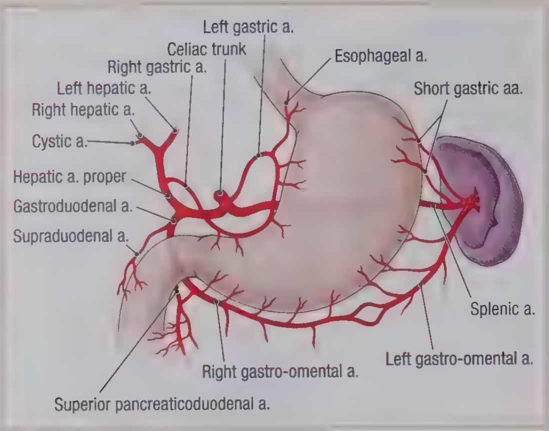


FIGURE 4.25 ■ Branches of the celiac trunk (artery) isolated. Anterior view.

5. Follow the gastroduodenal artery inferiorly and identify the **supraduodenal artery** supplying the first part of the duodenum, the **right gastro-omental (gastroepiploic) artery** supplying the greater curvature of the stomach, and the proximal aspect of the **superior pancreaticoduodenal artery** supplying the head of the pancreas.
6. Follow the common hepatic artery to the left side of the body toward its origin from the **celiac trunk**. *Note that the celiac trunk arises from the anterior surface of the abdominal aorta at the level of the 12th thoracic vertebra.*
7. Observe that the celiac trunk also gives rise to the **left gastric artery** and the **splenic artery**.
8. Use blunt dissection to follow the **left gastric artery** toward the esophagus and stomach and then follows the lesser curvature of the stomach within the lesser omentum.
9. Observe that the left gastric artery forms an anastomosis with the right gastric artery along the lesser curvature of the stomach. *Note that branches of the gastric arteries distribute to both the anterior and posterior surfaces of the stomach.*
10. Reflect the gastrocolic portion of the greater omentum superiorly and use blunt dissection to separate it from its attachment to the transverse colon while sparing its attachment to the greater curvature of the stomach.
11. Reflect the stomach superiorly and follow the **splenic artery** to the left for about 5 cm and verify that it lies against the posterior abdominal wall, is tortuous, and courses along the superior border of the pancreas where it may be partially imbedded. *Do not dissect the branches arising from the middle portion of the splenic artery at this time.*

### CLINICAL CORRELATION

#### Anatomical Variation in Cystic Arteries

ATLAS 4.57A, 4.62

The cystic artery usually arises from the right hepatic artery, but other origins are possible. Typically, the cystic artery passes posterior to the common hepatic duct, although in about a quarter of individuals, it may pass anteriorly as shown in FIGURE B4.2. Occasionally, the right hepatic artery itself arises from the superior mesenteric artery. An aberrant left hepatic artery may arise from the left gastric artery. During surgical removal of the stomach (gastrectomy), blood flow to an aberrant left hepatic artery could be interrupted, endangering the left lobe of the liver.

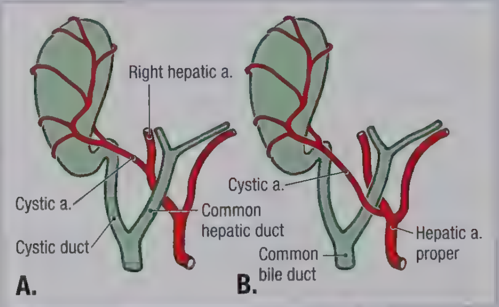


FIGURE B4.2 ■ Cystic artery arising from the right hepatic artery (**A**) (75%) or the hepatic artery proper (**B**) (24%). Anterior views.

12. Follow the splenic artery to its distal end where it gives the **short gastric arteries** to supply the fundus of the stomach. Observe that the short gastric arteries are embedded in the gastrosplenic ligament.
13. Observe that near its distal end, the splenic artery also gives rise to the **left gastro-omental (gastroepiploic) artery**, which courses in the greater omentum about 2 cm away from the greater curvature of the stomach.
14. Find the **right gastro-omental artery** from its origin off the gastroduodenal artery and follow it along its path within the greater omentum near the right end of the greater curvature of the stomach. The right gastro-omental artery anastomoses with the left gastro-omental artery along the greater curvature of the stomach.

## Spleen

ATLAS 4.30, 4.33, 4.35; VIDEO 4.5.4

***Dissection Note:*** The spleen is the largest hematopoietic organ in the body and its size and weight may vary

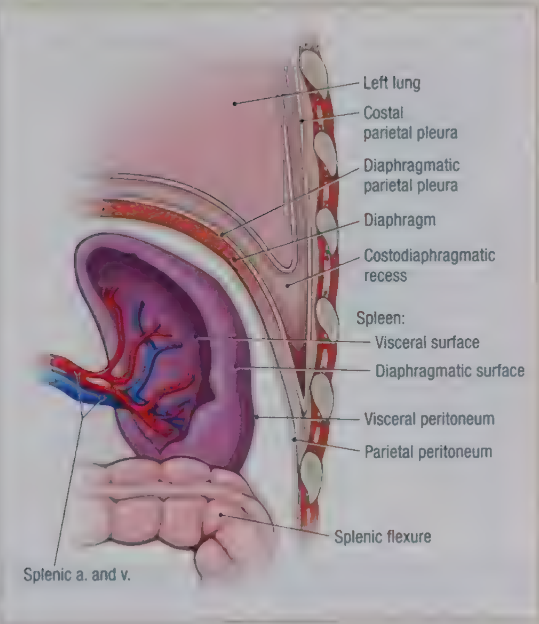


FIGURE 4.26 ● Relationships of the spleen to the thoracic wall. Anterior view.

considerably depending on the blood volume that it contained and the health of the individual during life.

1. Refer to FIGURE 4.26.
2. Use your left hand to retract the fundus of the stomach to the right and use your right hand to gently pull the spleen anteriorly.
3. Observe that the spleen has a smooth **diaphragmatic surface** and sharp anterior, inferior, and superior borders. *Note that the superior border of the spleen is often notched due to its pattern of embryological development.*
4. Observe that the **visceral surface of the spleen** is related to four organs: the **stomach**, the **left kidney**, the **transverse colon (left colic flexure)**, and the **pancreas**.
5. Observe that the diaphragmatic surface of the spleen is related to the diaphragm and **ribs 9, 10, and 11**.
6. Observe that the spleen is an intraperitoneal organ suspended within the abdominal cavity by the gastrosplenic ligament, from the greater curvature of the stomach, and splenorenal (lienorenal) ligaments, to the body wall anterior to the left kidney.
7. Identify the visceral peritoneum along the diaphragmatic surface of the spleen and observe the close proximity to the parietal peritoneum along the inferior aspect of the diaphragm.
8. Observe the close proximity of the spleen to the **inferior lobe of the left lung**, the **costodiaphragmatic recess**, and ribs 9 through 11.

**CLINICAL CORRELATION**

### Lacerated Spleen and Splenomegaly

ATLAS 4.35

The relationship of the spleen to ribs 9, 10, and 11 is of clinical importance in evaluating rib fractures due to blunt trauma or penetrating wounds as shown in FIGURE B4.3. A lacerated spleen bleeds profusely into the abdominal cavity and may have to be removed surgically (splenectomy). During thoracentesis (pleural tap), invasive removal of air or fluid from the pleural cavity, there is a risk of puncturing the spleen.

Splenomegaly is enlargement of the spleen due to infection, liver disease, or some cancers. The spleen is considered enlarged when it can be palpated inferior to the costal margin during physical examination.

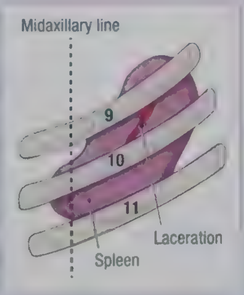


FIGURE B4.3 ● Lacerated spleen. Lateral view.

## Liver

ATLAS 4.50, 4.51; VIDEO 4.5.5

***Dissection Note:*** To study the surface features of the liver, it must first be detached from the diaphragm.

1. Refer to FIGURE 4.27.
2. Use scissors to cut the **falciform ligament** between the liver and diaphragm, extending the incision superiorly to the level of the **coronary ligament** anteriorly.
3. Gently pull the liver inferiorly and extend the cut bilaterally through the coronary ligament toward the **right** and **left triangular ligaments** along the inferior surface of the diaphragm.
4. Use scissors to cut the **inferior vena cava** between the liver and the diaphragm.
5. Insert your fingers between the liver and the diaphragm and gently tear the connective tissue attaching the liver directly to the diaphragm across the **bare area** of the liver.
6. On the posterior aspect of the liver, cut the posterior layer of the coronary ligament freeing the liver from the diaphragm.

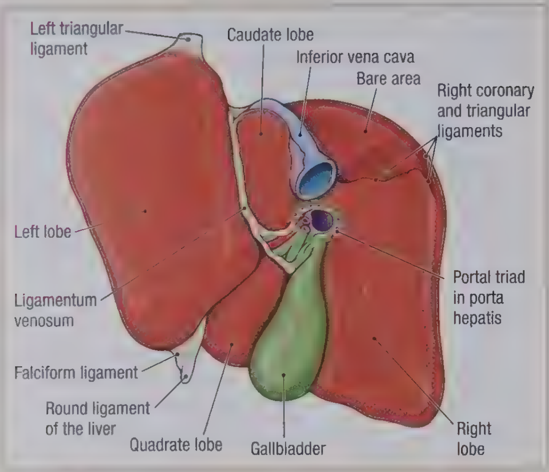


FIGURE 4.27 ■ Visceral surface of the liver. Inferior view.

7. Elevate the inferior border of the liver and cut the inferior vena cava again as close to the inferior surface of the liver as possible. The two cuts through the inferior vena cava will leave a short segment of vena cava within the liver.
8. The liver should now be freely mobile but attached to the other abdominal viscera by the **portal triad**; the bile duct, the hepatic artery proper, and the hepatic portal vein. Move the liver carefully to avoid tearing the vessels of the portal triad.
9. Examine the **liver** and note that the **right lobe** is approximately six times larger than the **left lobe** and that the sharp **inferior border** of the liver separates its **visceral surface** from its **diaphragmatic surface**.
10. Identify the **bare area** on the posterior aspect of the diaphragmatic surface of the liver and observe that it is bound by the cut edges of the **coronary ligament**. *Note that in this location, the liver was immediately adjacent to the diaphragm and not covered by peritoneum.*
11. Examine the **visceral surface** of the liver and identify the approximately H-shaped set of fissures and fossae defining its four lobes. Observe that the **ligamentum venosum** and **falciform ligament** occupy the left fissure of the "H" and that the **gallbladder** and **inferior vena cava** occupy the fossae that form the right side of the "H."
12. Identify the **porta hepatis** forming the horizontal bar of the "H." Recall that the structures passing through the hepatoduodenal ligament (bile ducts, hepatic arteries, hepatic portal vein, lymphatics, and autonomic nerves) enter or leave the liver at the porta hepatis.
13. Identify the **caudate lobe** between the inferior vena cava and the ligamentum venosum and the **quadrate lobe** between the round ligament of the liver and the gallbladder.
14. Examine the small segment of the **inferior vena cava** attached to the liver and remove any coagulated blood from within the vessel. Observe that several **hepatic veins** drain directly from the liver into the inferior vena cava.
15. Two common conventions are used to divide the liver. The first divides the liver into **right and left anatomical lobes** using the falciform ligament as a guide. The second divides the liver by the pattern of bile drainage and vascular supply. In this scheme, right and left livers are separated by the inferior vena cava and ultimately divided into eight hepatic segments.
16. The liver has a substantial lymphatic drainage. At the porta hepatis, small lymph vessels drain into **hepatic lymph nodes**, which follow lymphatic vessels accompanying the hepatic arteries toward **celiac lymph nodes** located around the celiac trunk. Lymph from the liver also drains posteriorly into **phrenic nodes**.

CLINICAL CORRELATION

### Liver Enlargement

ATLAS 4.55

The liver may undergo pathologic changes that could be encountered during dissection. The liver may be enlarged, which happens in liver congestion due to cardiac insufficiency (cardiac cirrhosis), or it may be small and have fibrous nodules indicating cirrhosis of the liver. Because the liver is essentially a capillary bed downstream from the gastrointestinal tract, metastatic tumor cells are often trapped within it, resulting in secondary tumors.

## Gallbladder

ATLAS 4.56, 4.57, 4.59A; VIDEO 4.5.6

***Dissection Note:*** The gallbladder is usually stained dark green by bile, which leaks through the wall of the gallbladder after death, often staining the surrounding tissue as well.

1. Refer to FIGURE 4.28.
2. Replace the liver into its correct anatomical position.
3. Confirm that the gallbladder is located near the tip of the ninth costal cartilage in the midclavicular line.
4. Observe that the distal end of the gallbladder, or the **fundus**, is free of the liver and directed anteriorly. The attached portion of the gallbladder is the **body**, whereas the **neck** is the narrow portion leading toward the biliary tree.
5. Lift the inferior border of the liver to expose the visceral surface. Use blunt dissection to carefully remove the gallbladder from its fossa.

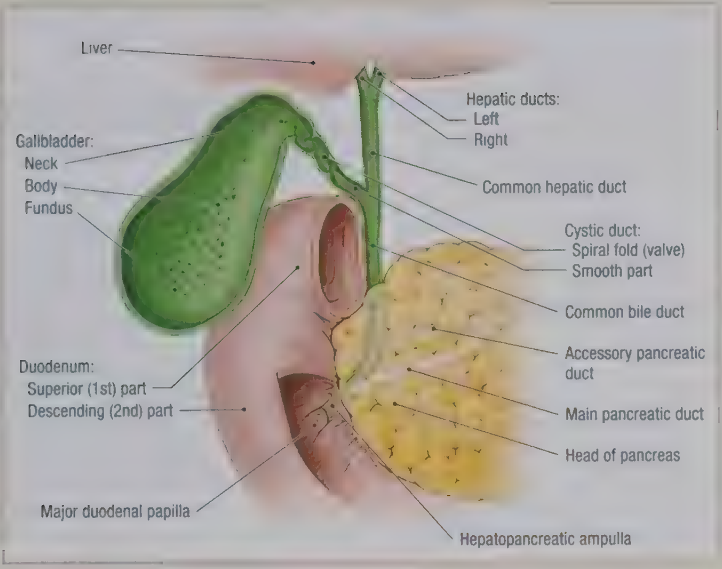

Liver
Hepatic ducts:
Left
Right
Gallbladder:
Neck
Body
Fundus
Common hepatic duct
Cystic duct:
Spiral fold (valve)
Smooth part
Common bile duct
Accessory pancreatic duct
Duodenum:
Superior (1st) part
Descending (2nd) part
Main pancreatic duct
Head of pancreas
Major duodenal papilla
Hepatopancreatic ampulla

FIGURE 4.28 ■ Gallbladder and biliary tree and isolated. Anterior view.

6. Review the course of the **cystic artery** from the hepatic vessels. *Note that the cystic artery is often stained green by bile and is often fragile making it difficult to dissect.*
7. Use scissors to make a longitudinal cut through the wall of the gallbladder, beginning at the fundus and continuing through the neck into the cystic duct. If gallstones are present, remove them.
8. Look for the **spiral fold (valve)**, which is a fold in the mucosal lining of the neck continuing into the **cystic duct** allowing for bidirectional flow in and out of the organ.
9. Observe that the biliary system connects with the **main pancreatic duct** to drain into the **second (descending) portion of the duodenum** via the **major duodenal papilla**.

## Dissection Follow-up

1. Review the location of each organ relative to the abdominal quadrant system.
2. Review the branches of the celiac trunk.
3. Review the relationships of the structures in the hepatoduodenal ligament.
4. Review the boundaries of the omental foramen.
5. Review the parts of the organs dissected and their relationships to surrounding structures.
6. Return the gallbladder and other abdominal organs to their correct anatomical positions.
7. Use an embryology textbook to review the development of the embryonic foregut, liver, and pancreas and their respective mesenteries.

# SUPERIOR MESENTERIC ARTERY AND SMALL INTESTINE

## Dissection Overview

The superior mesenteric artery arises from the anterior surface of the abdominal aorta about 1 cm inferior to the celiac trunk at vertebral level L1. At its origin, the superior mesenteric artery lies posterior to the neck of the pancreas. When the superior mesenteric artery emerges from posterior to the neck of the pancreas, it passes anterior to the pancreatic uncinate process, the third part of the duodenum, and the left renal vein. The superior mesenteric artery then enters the mesentery of the small intestine where it courses into the right lower quadrant, toward the terminal end of the ileum.

The superior mesenteric artery delivers the majority of the blood supply to both the small intestine and the large intestine, up to the right two-thirds of the transverse colon, the region of the embryonic midgut. The small intestine consists of the duodenum, jejunum, and ileum and is the major site of digestion of food and absorption of nutrients. The small intestine has elaborate folds of mucosa that increase the surface area for absorption and a rich blood supply to transport the absorbed nutrients.

The order of dissection will be as follows: The mesentery will be examined. The branches of the superior mesenteric artery that supply the jejunum, ileum, cecum, ascending colon, and transverse colon will be dissected. The external features of the jejunum and ileum will be studied. The remainder of the field of supply of the superior mesenteric artery (to the duodenum and pancreas) will be dissected later as these structures lie deep to the attachment of the transverse mesocolon making access somewhat more complex.

## Dissection Instructions

### Superior Mesenteric Artery and Vein

ATLAS 4.29A, 4.31B, 4.44; VIDEO 4.6.1

1. Refer to FIGURE 4.29.
2. Reflect the greater omentum and transverse colon superiorly over the costal margin so the posterior surface of the transverse mesocolon faces anteriorly.
3. Position the coils of the **jejunum** and **ileum** to the left side of the abdomen so the right side of the mesentery faces anteriorly.
4. Observe that the **root of the mesentery**, the point of origination, is attached to the posterior abdominal wall along an oblique line from the left upper quadrant to the right lower quadrant.
5. Remove the anterior portion of the peritoneum on the right side of the mesentery to expose the branches of the superior mesenteric artery. To do so, make a small incision through the anterior layer of the peritoneum and then use forceps to grasp it and slowly peel it away while using a probe to separate it from the underlying blood vessels.
6. Remove the parietal peritoneum from the posterior abdominal wall on the right side of the mesentery as far laterally as the ascending colon. *Note that all portions of the peritoneum on the surface of an organ are visceral, whether it is a retroperitoneal organ or an intraperitoneal organ.*
7. Identify the **superior mesenteric artery** coursing within the mesentery proper. Use blunt dissection to trace the superior mesenteric artery proximally

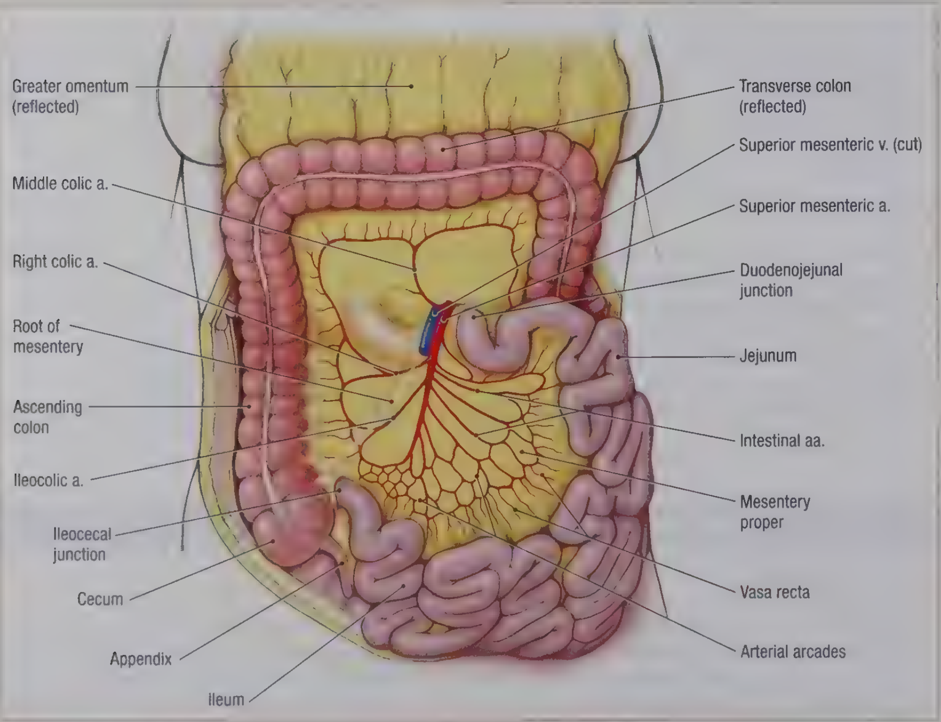

Greater omentum (reflected)
Middle colic a.
Right colic a.
Root of mesentery
Ascending colon
Ileocolic a.
Ileocecal junction
Cecum
Appendix
Ileum
Transverse colon (reflected)
Superior mesenteric v. (cut)
Superior mesenteric a.
Duodenojejunal junction
Jejunum
Intestinal aa.
Mesentery proper
Vasa recta
Arterial arcades

FIGURE 4.29 Mesentery proper and branches of the superior mesenteric artery. Anterior view.

toward its origin off the abdominal aorta and observe that it crosses anterior to the third part of the duodenum.

**CLINICAL CORRELATION**

### Superior Mesenteric Artery Syndrome

ATLAS 4.68

The third part of the duodenum can become compressed between the superior mesenteric vessels and the abdominal aorta leading to superior mesenteric artery syndrome, a gastrovascular disorder. Blockage of the duodenum results in blockage of the digestive tract and though rare may be life-threatening. The superior mesenteric artery may also compress the left renal vein against the abdominal aorta in "nutcracker syndrome", resulting in insufficient venous drainage of the left kidney, left adrenal gland, and left gonad.

8. Use blunt dissection to clean a short portion of the superior mesenteric artery, which is embedded in a variable amount of mesenteric fat. As you dissect, observe the **superior mesenteric plexus of nerves**, a dense autonomic nerve network surrounding the blood vessels.
9. Identify the **superior mesenteric vein** positioned along the right side of the superior mesenteric artery. The superior mesenteric vein is formed by tributaries that correspond in name and position to many of the branches of the superior mesenteric artery.
10. Follow the superior mesenteric vein superiorly and observe that posterior to the pancreas, it joins the splenic vein to form the **hepatic portal vein**.
11. Return to the mesentery proper and identify one or two **mesenteric lymph nodes**, if visible, along the branches of the superior mesenteric vessels. The mesentery may contain up to 200 lymph nodes, which drain into the **superior mesenteric lymph nodes** near the origin of the superior mesenteric artery from the abdominal aorta.
12. To facilitate identification of the intestinal arteries, the lymph nodes and autonomic nerves may be removed to clear the dissection field.
13. Observe that the superior mesenteric artery has 15 to 18 **intestinal arteries** originating from the left side of the superior mesenteric artery and supplying the jejunum and ileum. *Note that the inferior pancreaticoduodenal artery is usually the first branch of the superior mesenteric artery; this vessel will be dissected with the duodenum.*
14. Observe that the intestinal arteries end in straight terminal branches called **vasa recta** (straight arteries), which are interconnected by **arterial arcades**.
15. Identify the **middle colic artery** arising from the anterior surface of the superior mesenteric artery and coursing through the transverse mesocolon to supply the transverse colon.
16. Clean the middle colic artery along a short distance and observe that it divides into a right and a left branch along the margin of the transverse colon.
17. Identify the **right colic artery** arising from the right side of the superior mesenteric artery and passing to the right in a retroperitoneal position to supply the ascending colon.
18. Clean the right colic artery and observe that it often divides into a superior branch and an inferior branch.
19. Refer to FIGURE 4.30.
20. To the left of the superior mesenteric artery, identify the vast blood supply to the proximal jejunum and observe that only one or two **arcades** are found between adjacent **intestinal arteries**, resulting in relatively long **vasa recta**.
21. Gently elevate a portion of the peritoneum and make an effort to clean and isolate a portion of the jejunal vasculature along a short portion of the organ's length.

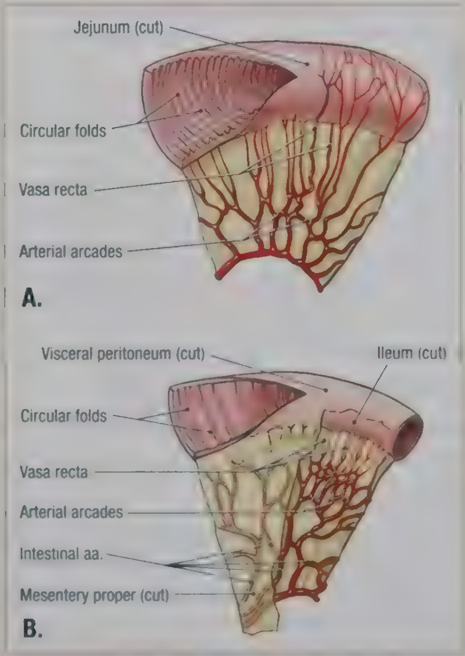


FIGURE 4.30 ● Intestinal blood supply to the jejunum (A) and ileum (B). Anterior view.

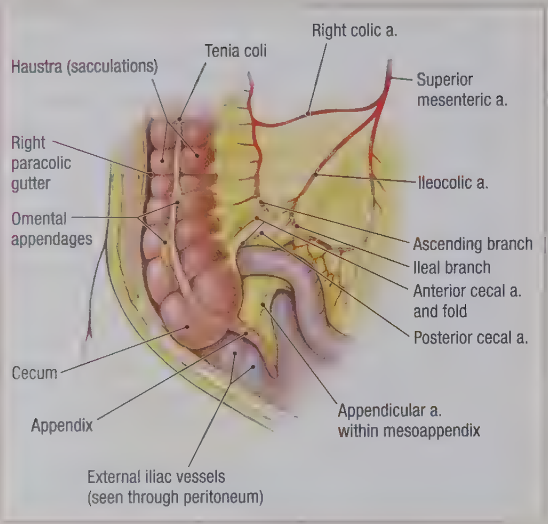

Right colic a.
Tenia coli
Haustra (sacculations)
Superior mesenteric a.
Right paracolic gutter
Ileocolic a.
Omental appendages
Ascending branch
Ileal branch
Anterior cecal a. and fold
Posterior cecal a.
Cecum
Appendix
Appendicular a. within mesoappendix
External iliac vessels (seen through peritoneum)

FIGURE 4.31 ■ Branches of the ileocolic artery. Anterior view.

22. Examine the distal ileum and note that four or five **arcades** occur between adjacent **intestinal arteries**, resulting in relatively short **vasa recta**.
23. Gently elevate a portion of the **peritoneum** and make an effort to clean and isolate a portion of the ileal vasculature along a short portion of the organ's length.
24. Refer to FIGURE 4.31.
25. Identify and clean the **ileocolic artery** arising from the distal extent of the superior mesenteric artery coursing toward the right lower quadrant in a retroperitoneal position to supply the cecum.
26. If the appendix has not been surgically removed in the cadaver, make an effort to identify and clean the **appendicular artery**, a small vessel arising from the ileocolic artery, which anastomoses with intestinal branches and the right colic artery.

## Small Intestine

ATLAS 4.40, 4.41; VIDEO 4.6.2

***Dissection Note:*** The jejunum and ileum will be studied together because the transition from one to the other is gradual.

1. Refer to FIGURE 4.32
2. Move the intraperitoneal portion of the small intestine to the left side of the abdominal cavity and follow the jejunum proximally to find the **duodenojejunal junction**.
3. Gently pull the proximal jejunum away from the posterior abdominal wall and observe that the small intestine has limited mobility as it is anchored at the duodenojejunal junction by the **suspensory ligament of the duodenum**, a fibromuscular band arising from the right crus of the diaphragm. *Note that the suspensory ligament passes posterior to the pancreas; thus, it cannot be seen at this time.*
4. Palpate the small intestine and note that the wall of the jejunum is thicker than the wall of the ileum and that the overall diameter of the jejunum is larger.
5. Identify the termination of the ileum where it empties into the **cecum** at the **ileocecal junction**.
6. Verify that the **root of the mesentery** crosses the posterior abdominal wall from the duodenojejunal junction to the ileocecal junction. Observe that the mesentery is somewhat "fan-shaped", with the root about 15 cm long, and its intestinal attachment nearly 6 m long.

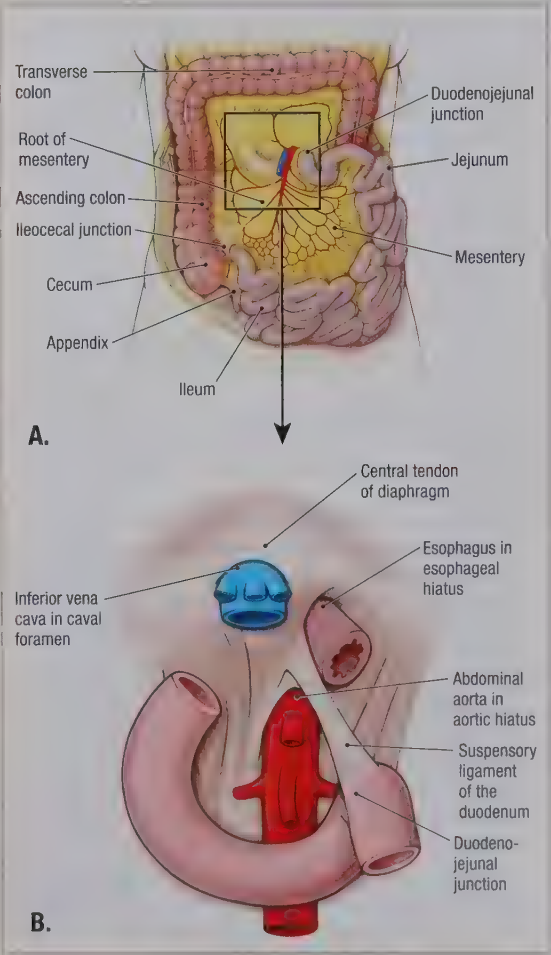

Transverse colon
Duodenojejunal junction
Root of mesentery
Jejunum
Ascending colon
Ileocecal junction
Mesentery
Cecum
Appendix
Ileum
A.
Central tendon of diaphragm
Esophagus in esophageal hiatus
Inferior vena cava in caval foramen
Abdominal aorta in aortic hiatus
Suspensory ligament of the duodenum
Duodeno-jejunal junction
B.

FIGURE 4.32 ■ **A.** Duodenojejunal junction. **B.** Suspensory ligament of the duodenum isolated. Anterior views.

## Dissection Follow-up

1. Review the location of the jejunum and ileum relative to the abdominal quadrant system.
2. Review the relationships of the jejunum and ileum to surrounding structures.
3. Review the branches of the superior mesenteric artery.
4. Replace the small intestine and other displaced abdominal contents in their correct anatomical position.
5. Use an embryology textbook to review the derivatives of the embryonic midgut.

# INFERIOR MESENTERIC ARTERY AND LARGE INTESTINE

## Dissection Overview

The inferior mesenteric artery arises from the anterior surface of the abdominal aorta at vertebral level L3. The inferior mesenteric artery supplies the left third of the transverse colon, descending colon, sigmoid colon, and the superior one-third of the rectum. Except for the branches that pass through the sigmoid mesocolon to supply the sigmoid colon, the inferior mesenteric artery and its branches lie retroperitoneally. Recall that the inferior mesenteric artery supplies the region of the embryonic hindgut.

The large intestine consists of the cecum (with attached vermiform appendix), colon (ascending, transverse, descending, and sigmoid), rectum, and anal canal. Absorption of water from fecal material is a major function of the large intestine. The relatively smooth mucosal surface of the large intestine is well suited for this function because a smooth surface is less likely to impede the movement of progressively more solid fecal material.

The order of dissection will be as follows: The inferior mesenteric artery and its branches will be dissected. The external features of the large intestine will be studied.

## Dissection Instructions

### Inferior Mesenteric Artery and Vein

ATLAS 4.31B, 4.46; VIDEO 4.7.1

1. Refer to FIGURE 4.33.
2. Reflect the transverse colon and greater omentum superiorly over the costal margin to expose the posterior surface of the **transverse mesocolon**.
3. Move the small intestine to the right so the **descending colon** is visible from the left colic flexure to the **sigmoid colon**.
4. Identify the **inferior mesenteric artery** where it arises from the abdominal aorta, commonly posterior to the third part of the duodenum. If you have trouble finding the inferior mesenteric artery, locate one of its branches in the sigmoid mesocolon and trace that branch back to the main vessel and then proceed with the dissection of the peripheral branches.
5. Use a probe to clean the **branches of the inferior mesenteric artery** beginning with the **left colic artery**, which supplies the descending colon and the left third of the transverse colon. *Note that the left colic artery anastomoses with the middle colic branch of the superior mesenteric artery and the ascending branch of the first sigmoid artery.*
6. Identify three or four **sigmoid arteries** supplying the sigmoid colon. Sigmoid arteries pass through the sigmoid mesocolon and form arcades similar to those of the intestinal arteries.

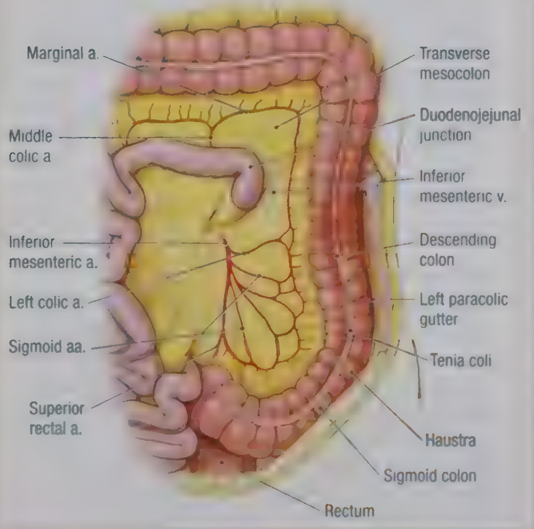


FIGURE 4.33 ● Branches of the inferior mesenteric artery. Anterior view.

7. Identify the **superior rectal artery** descending into the pelvic cavity to supply the proximal part of the rectum. Follow the superior rectal artery until it divides into a **right branch** and a **left branch**, which descend into the pelvic cavity on either side of the rectum.

8. Superior to the left colic artery, identify the **marginal artery of the colon** coursing along the inner circumference of the large intestine near the splenic flexure. Observe that the marginal artery reaches the middle colic artery to form an anastomosis between the superior and inferior mesenteric arteries.
9. Observe that the tributaries of the **inferior mesenteric vein** correspond to the branches of the inferior mesenteric artery.
10. Clean a portion of the inferior mesenteric vein and observe that it ascends on the left side of the inferior mesenteric artery.
11. Follow the inferior mesenteric vein superiorly to where it passes posterior to the pancreas to join either the splenic vein or the superior mesenteric vein as a tributary of the hepatic portal vein.
12. Identify the left ureter within the retroperitoneal space in close proximity to the inferior mesenteric vein and artery. Observe that the vessels can be differentiated from the ureter because they descend in the abdominal cavity anterior to the ureter.
13. Lymph vessels that accompany the branches of the inferior mesenteric artery drain the descending colon and sigmoid colon. The lymphatic vessels drain into the **inferior mesenteric nodes** located around the origin of the inferior mesenteric artery from the abdominal aorta. *Note that in an embalmed specimen, it may be difficult to locate the lymphatic vessels; however, lymph nodes are generally identifiable in the mesentery.*
14. Return the small intestine and transverse colon to their correct anatomical positions.

## Large Intestine

ATLAS 4.48, 4.49; VIDEO 4.7.2

1. Refer back to FIGURE 4.31.
2. Beginning in the right lower quadrant, identify the various components of the **large intestine** beginning with the **cecum**.
3. Observe that the cecum is quite mobile and often almost completely invested by peritoneum, although it does not have a named mesentery. *Note that the cecum is classified as an intraperitoneal organ; however, the length of its mesentery and degree of its mobility varies considerably from individual to individual.*
4. If visible, identify the **anterior** and **posterior cecal arteries** arising from the **ileocolic artery** to provide blood supply to the cecum.
5. Elevate the cecum slightly and observe the close relationship to the underlying **external iliac vessels** coursing toward the lower limb.
6. Identify the **appendix (vermiform appendix)** attached to the end of the cecum in one of several positions, although if present, most likely in a retrocecal position.
7. Observe that the appendix is suspended on a mesentery called the **mesoappendix** and that the **appendicular artery** is found within the mesoappendix.

CLINICAL CORRELATION

### Appendicitis

ATLAS 4.43

The appendix is a blind-ended intraperitoneal organ with limited known functionality, although high clinical relevancy due to the common need to remove the organ when it becomes inflamed, as seen in appendicitis. In the majority of individuals, the appendix lies in a retrocecal position posterior to the cecum; however, in some individuals, it may be found suspended inferior to the cecum even extending into the pelvic cavity, with a low ratio of other orientations, as shown in FIGURE B4.4. Verification of the orientation in the sick individual should be assessed prior to removal in an appendectomy procedure.

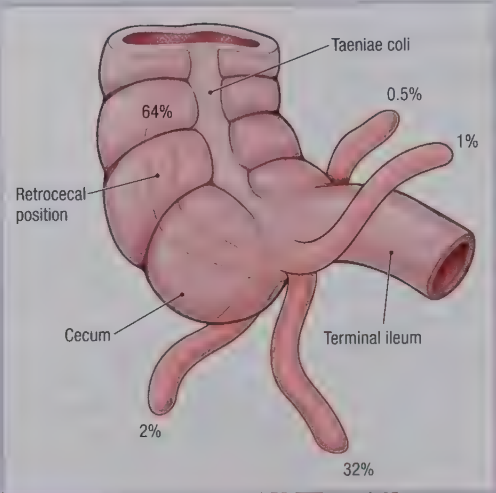


FIGURE B4.4 ■ Variations in the position of the appendix. Anterior view.

8. On the external surface of the large intestine, observe three features that distinguish it from the small intestine: The **teniae coli** are three narrow bands of longitudinal muscle running the length of the large intestine, the **haustra (sacculations)** are outpouchings of the wall of the colon, and the **omental appendices (epiploic appendages)** are small accumulations of fat covered by visceral peritoneum.

9. Refer back to FIGURE 4.30A and FIGURE 4.33.
10. Identify the **ascending colon** extending from the cecum to the **right colic flexure** and recall that it is a secondarily retroperitoneal organ.
11. Identify the **transverse colon** between the **right colic (hepatic) flexure** and the **left colic (splenic) flexure** and observe that the transverse colon is suspended by the **transverse** mesocolon and freely mobile at this location.
12. Verify that the left colic flexure lies at a more superior level than the right colic flexure due to the location of the liver.
13. Identify the **descending colon** from the left colic flexure to the left lower quadrant and recall that it is a secondarily retroperitoneal organ.
14. In the left lower quadrant, identify the **sigmoid colon** and its mesentery the **sigmoid mesocolon**.
15. Observe that the sigmoid colon is a mobile intraperitoneal organ that ends in the pelvis at the level of the S3 where it is continuous with the rectum.
16. Identify superior aspect of the **rectum** within the pelvic cavity. *Note that the rectum and anal canal are contained entirely within the pelvic cavity and will be dissected with the pelvic viscera.*

## Dissection Follow-up

1. Review the location of each part of the large intestine relative to the abdominal quadrant system.
2. Review the relationship of each part of the large intestine to the surrounding structures.
3. Review the branches of the superior mesenteric artery and inferior mesenteric artery that supply the large intestine.
4. Replace the large intestine and other displaced abdominal contents in their correct anatomical position.
5. Use an embryology textbook to review the derivatives of the embryonic hindgut.

# DUODENUM, PANCREAS, AND HEPATIC PORTAL VEIN

## Dissection Overview

The duodenum is the part of the small intestine between the stomach and the jejunum and is the recipient of the ducts of the liver, gallbladder, and pancreas. The pancreas lies within the bend of the duodenum with its head directed at the descending or second portion of the duodenum. The pancreas is both an endocrine and an exocrine organ and has a rich blood supply arising from the celiac trunk and the superior mesenteric artery.

The order of dissection will be as follows: The parts of the duodenum will be studied. The pancreas will be dissected. The formation of the hepatic portal vein will be demonstrated.

## Dissection Instructions

### Duodenum

ATLAS 4.37, 4.38; VIDEO 4.8.1

1. Refer to FIGURE 4.34.
2. Reflect the transverse colon and greater omentum superiorly over the costal margin.
3. Use blunt dissection to separate and remove the transverse mesocolon and connective tissue overlying the anterior surface of the duodenum and pancreas.
4. Identify the **four parts of the duodenum** beginning with the **superior (1st) part** at the L1 vertebral level, coursing in the transverse plane where it continues from the pylorus of the stomach.
5. Observe that the hepatoduodenal ligament, a portion of the lesser omentum attaches to the first part of the duodenum. *Note that the first part is mostly intraperitoneal and has an expanded initial part called the ampulla which clinicians often call the duodenal cap or duodenal bulb.*

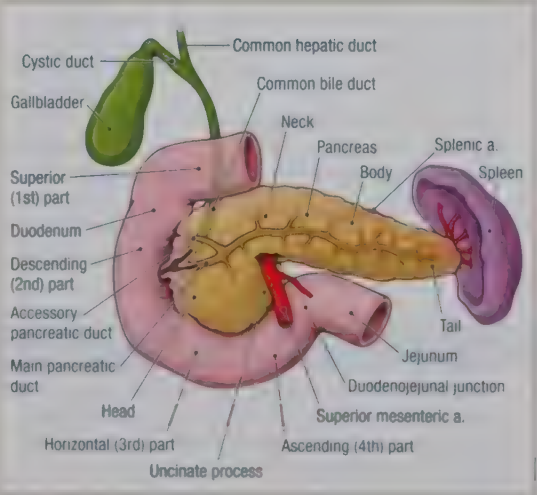


FIGURE 4.34 ● Pancreas and duodenum. Anterior view.

6. Identify the **descending (2nd) part** of the duodenum at the L2 vertebral level and observe that it is positioned to the right of midline and anterior to the hilum of the right kidney, right renal vessels, and inferior vena cava. *Note that the second part of the duodenum is retroperitoneal and receives the bile duct and the pancreatic duct.*
7. Identify the **horizontal (3rd) part** of the duodenum at the L3 vertebral level in a retroperitoneal location. Observe that it is crossed anteriorly by the superior mesenteric vessels and posteriorly by the inferior vena cava, the abdominal aorta, and the inferior mesenteric vein.
8. Identify the **ascending (4th) part** of the duodenum at the L2 vertebral level. *Note that the ascending part of the duodenum is retroperitoneal throughout most of its length until it turns anteriorly to join the jejunum at the duodenojejunal junction.*

## Pancreas

ATLAS 4.37, 4.38, 4.59B; VIDEO 4.8.2

1. Refer to FIGURE 4.34.
2. Identify the **pancreas** within the bend of the duodenum. *Note that it is a secondarily retroperitoneal organ that lies across the midline and is positioned against vertebral bodies L1–L3.*
3. Identify the **head of the pancreas** adjacent to the descending duodenum. Observe that the inferior vena cava lies posterior to the head of the pancreas.
4. At the inferior margin of the head of the pancreas, identify the **uncinate process**, a small projection that lies posterior to the superior mesenteric vessels.
5. Identify the **neck of the pancreas**, a short portion that lies anterior to the superior mesenteric vessels connecting the head and body of the pancreas.
6. Observe that the **body of the pancreas** extends from right to left and slightly superiorly as it crosses the abdominal aorta.
7. Identify the **tail of the pancreas**, the narrow, left end of the gland, which lies in the splenorenal ligament and contacts the hilum of the spleen.
8. Use a probe to bluntly dissect into the anterior surface of the head of the pancreas and find the **main pancreatic duct**. Follow the main pancreatic duct through the neck and into the body.
9. Make an effort to identify the smaller **accessory pancreatic duct** joining the superior side of the main pancreatic duct in the head of the pancreas.
10. Follow the common bile duct inferiorly and observe that it joins the main pancreatic duct near the left side of the descending part of the duodenum.
11. Refer to FIGURE 4.35.
12. Superior to the head of the pancreas, identify the **anterior and posterior superior pancreaticoduodenal arteries** arising from the **superior pancreaticoduodenal artery**, a branch of the **gastroduodenal artery**.
13. Inferior to the head of the pancreas, identify the **inferior pancreaticoduodenal artery** commonly arising as the most proximal branch of the superior mesenteric artery, although its origin is variable.
14. Return to the celiac trunk and follow the **splenic artery** as it passes to the left along the superior border of the pancreas.
15. Remove the remaining peritoneum over the anterior aspect of the pancreas and observe that up to 10 small branches of the splenic artery supply the body and tail of the pancreas, although only two will be named here: the **dorsal pancreatic artery** entering the neck of the pancreas and the **greater pancreatic (pancreatica magna) artery** entering the pancreas about halfway between the neck and the tail. Recall that the splenic artery also gave rise to the short gastric arteries and left gastro-omental artery.
16. The veins of the pancreas correspond to the arteries and drain into the superior mesenteric and splenic veins and ultimately are tributaries to the hepatic portal vein.

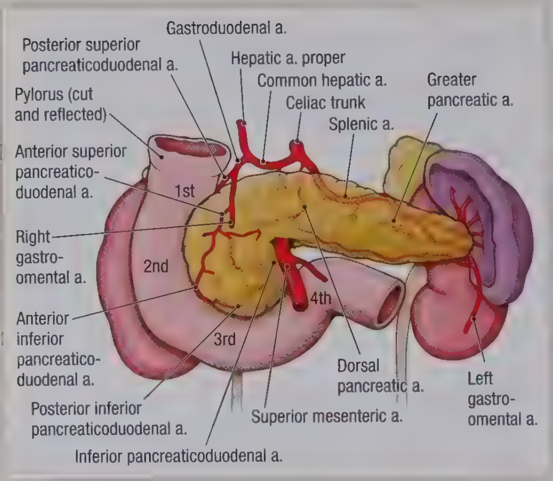

Gastroduodenal a.
Posterior superior pancreaticoduodenal a.
Hepatic a. proper
Common hepatic a.
Greater pancreatic a.
Pylorus (cut and reflected)
Celiac trunk
Splenic a.
Anterior superior pancreatico-duodenal a.
1st
Right gastro-omental a.
2nd
4th
Anterior inferior pancreatico-duodenal a.
3rd
Dorsal pancreatic a.
Left gastro-omental a.
Posterior inferior pancreaticoduodenal a.
Superior mesenteric a.
Inferior pancreaticoduodenal a.

FIGURE 4.35 ● Blood supply of the pancreas. Anterior view.

## Hepatic Portal Vein

ATLAS 4.38, 4.65; VIDEO 4.8.3

1. Refer to FIGURE 4.36.
2. Identify the **splenic vein** where it courses posterior to the pancreas and inferior to the splenic artery.
3. Use a probe or blunt dissection to isolate the splenic vein posterior to the body of the pancreas and observe that the splenic vein is typically flatter and straighter than the more tortuous thicker splenic artery.

4. Follow the splenic vein to the right where it is joined by the superior mesenteric vein to form the **hepatic portal vein**.
5. Follow the hepatic portal vein superiorly until it branches into the **right** and **left hepatic veins** each directed at their respective lobe of the liver. Recall that the hepatic portal vein ascends in the hepatoduodenal ligament to the porta hepatis. *Note that the bifurcation of the hepatic portal vein into the individual hepatic veins may not be visible outside the liver.*

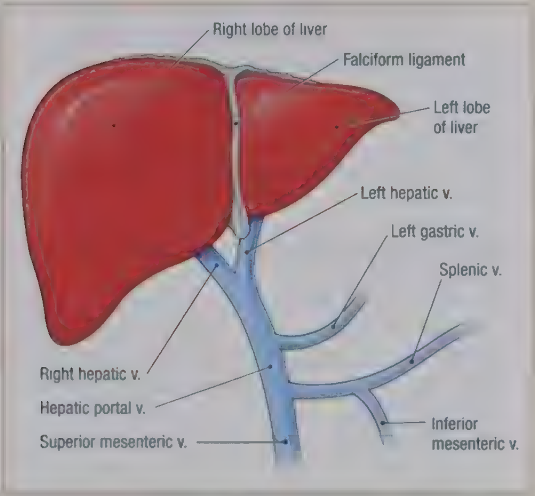


FIGURE 4.36 ● Hepatic portal vein. Anterior view.

6. Make an effort to identify the **left gastric vein** draining into the hepatic portal vein. *Note that this vessel may have been cut during dissection of the branches of the celiac trunk.*
7. Return to the field of distribution of the inferior mesenteric vein and follow it superiorly until it drains into the superior mesenteric vein, the splenic vein, or the junction of the superior mesenteric and splenic veins.

**CLINICAL CORRELATION**

### Portal Hypertension

ATLAS 4.66

The hepatic portal system of veins drains a significant portion of the intestinal tract and has no valves. When the hepatic portal vein becomes blocked, blood pressure increases in the hepatic portal system (portal hypertension), as can occur with cirrhosis of the liver, and its tributaries become engorged. Portal hypertension causes gastroesophageal varices, enlargement of the gastric and esophageal veins, which if ruptured may lead to internal bleeding, a dangerous complication of portal hypertension.

Four portal-systemic (portal-caval) anastomoses exist within the abdomen to allow for alternative routes of venous return: the gastroesophageal (left gastric vein/esophageal veins/azygos vein), the anorectal (superior rectal vein/middle and inferior rectal veins), the paraumbilical (paraumbilical veins/superficial epigastric veins), and the retroperitoneal (colic veins/retroperitoneal veins).

## Dissection Follow-up

1. Review the relationship of each part of the duodenum to the surrounding structures.
2. Review the branches of the celiac trunk and superior mesenteric artery.
3. Review the blood supply to the pancreas and duodenum.
4. Review the formation and field of drainage of the hepatic portal vein.
5. Trace a drop of blood from the small intestine to the inferior vena cava, naming all veins that are encountered along the way. Repeat this exercise beginning at the descending colon.
6. Replace the displaced abdominal contents in their correct anatomical position.
7. Use an embryology textbook to review the development of the liver, pancreas, and duodenum.

# REMOVAL OF THE GASTROINTESTINAL TRACT

## Dissection Overview

The digestive tract collectively serves to take in nourishment for the body and expel waste. The mechanical process of digestion begins in the oral cavity and descends via the esophagus to reach the stomach and duodenum where digestion continues. Absorption of the nutrients and chemical compounds occurs in the small intestine, primarily in the jejunum, whereas water reabsorption occurs in the large intestine, primarily in the ascending colon. The descending colon, sigmoid colon, and rectum store fecal matter prior to defecation via the anus.

The posterior features of the various parts of the gastrointestinal tract and the posterior abdominal wall are best dissected with the gastrointestinal tract removed from the abdominal cavity; however, many of the relationships may still be studied without complete removal. If removal of the gastrointestinal tract is either not a part of your labs' dissection protocol, or time does not permit, simply orient the abdominal contents to one side or the other leaving the tract in situ.

The order of dissection will be as follows: The stomach will be opened and reviewed. The small and large intestine will be opened regionally and reviewed. The rectum and esophagus will be cut, using string ligatures to prevent spilling of their contents. The arteries to the gastrointestinal tract (celiac trunk, superior mesenteric artery, and inferior mesenteric artery) will be cut close to the aorta. The gastrointestinal tract will then be removed en bloc and reviewed outside of the body.

## Dissection Instructions

### Opening the Stomach

ATLAS 4.32; VIDEO 4.9.1

1. Elevate the diaphragm and identify the opening of the **esophageal hiatus** allowing passage of the esophagus into the abdominal cavity.
2. Use blunt dissection to clean the anterior surface of the esophagus and cardia of the stomach.
3. Refer to FIGURE 4.37.
4. Use scissors to open the stomach along its anterior surface paralleling the curve of the lesser curvature (**Cut 1**).
5. Extend the cut through the fundus of the stomach horizontally toward the greater curvature of the stomach (**Cut 2**).
6. Open the stomach and on its inner surface identify the **gastric folds (rugae)**. If necessary, rinse and clean the mucosal surface to observe the internal structures. *Note that the rugae will flatten out with stomach expansion and are thus not always present.*
7. Observe the narrowing of the body of the stomach inferiorly at the **pyloric antrum** just prior to the **pyloric canal**.
8. Insert a probe into the pyloric canal and extend the cut through the anterior surface of the stomach into pylorus (**Cut 3**).
9. Create a short vertical incision at the end of the horizontal incision within the pylorus and open the pyloric region of the stomach (**Cut 4**).
10. Identify the **pyloric sphincter** at the end of the pyloric canal, which controls the passage of food into the **duodenum** through the **pyloric orifice**.

### Opening the Small and Large Intestines

ATLAS 4.37, 4.40, 4.43; VIDEO 4.9.2

1. Extend the longitudinal cut from the pylorus of the stomach through the anterior wall of the duodenum following the shape of the duodenum through its four parts (**Cut 5**).
2. Refer to FIGURE 4.38.
3. Spread open the second part of the duodenum and identify the **circular folds (plicae circulares)**. *Note that unlike the rugae of the stomach, the folds of the small intestine are transversely oriented and are always present.*

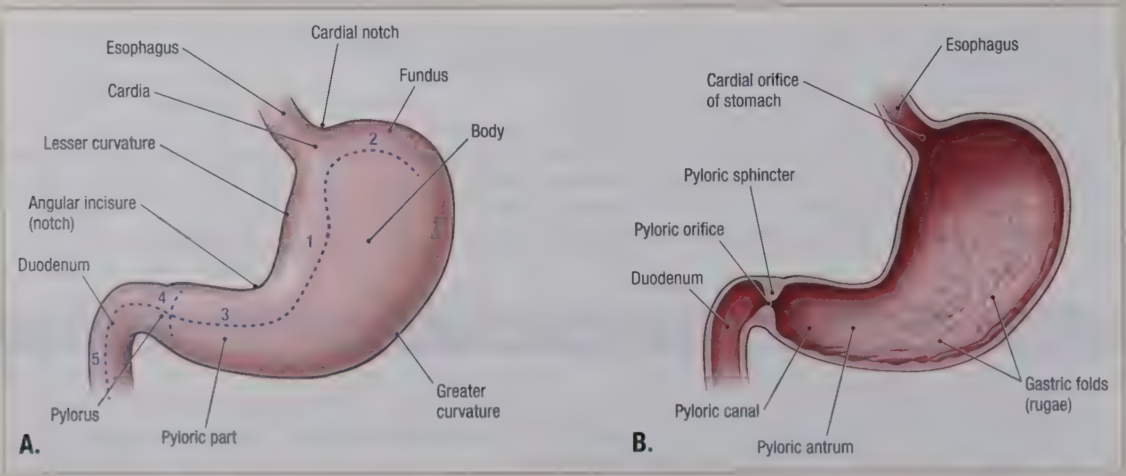


FIGURE 4.37 ■ **A.** Cuts to open the stomach. **B.** Internal features of the stomach. Anterior views.

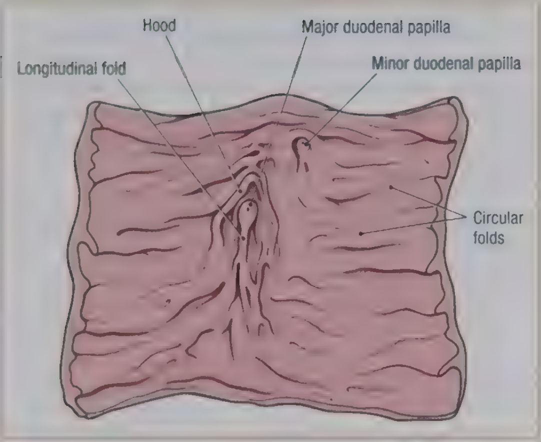

Hood
Major duodenal papilla
Longitudinal fold
Minor duodenal papilla
Circular folds

FIGURE 4.38 ● Mucosal features of the descending duodenum and duodenal papillae. Isolated view.

4. Identify the **major (greater) duodenal papilla**, or ampulla of Vater, an elevation of mucosa on the posterior-medial wall of the second part of the duodenum, which allows passage of the hepatopancreatic duct, the combined main pancreatic duct and common bile duct. *Note that the regulation of the opening is controlled by a small circular muscle in the wall of the papilla known as the hepatopancreatic sphincter (sphincter of Oddi).*
5. Identify the **minor (lesser) duodenal papilla**, the site of drainage of the accessory pancreatic duct, approximately 2 cm superior to the major duodenal papilla (if present).
6. Refer to FIGURE 4.39.
7. Use scissors to make one 5-cm longitudinal cut in the **proximal jejunum** and another in the **distal ileum**.
8. Rinse the mucosa within the two cut regions of the small intestine to compare the internal anatomy and observe that the plicae circulares are larger and closer together in the jejunum than they are in the ileum.
9. Make an effort to identify the **solitary lymph nodes**, small raised bumps on the internal aspect of the ileum. *Note that the lymph nodules are present elsewhere in the digestive tract, although they are less visible. The prevalence of lymphatics within the ileum and cecal region is indicative of its role in assisting the immune system.*
10. Refer to FIGURE 4.40.
11. Use scissors to make a cut approximately 7.5 cm long in the anterior wall of the **cecum**. Rinse the mucosa and identify the **ileocecal orifice** located between the **superior and inferior lips of the ileocecal valve**.
12. Identify the **opening of the (vermiform) appendix** inside the cecum, using the appendix as a landmark for orientation.

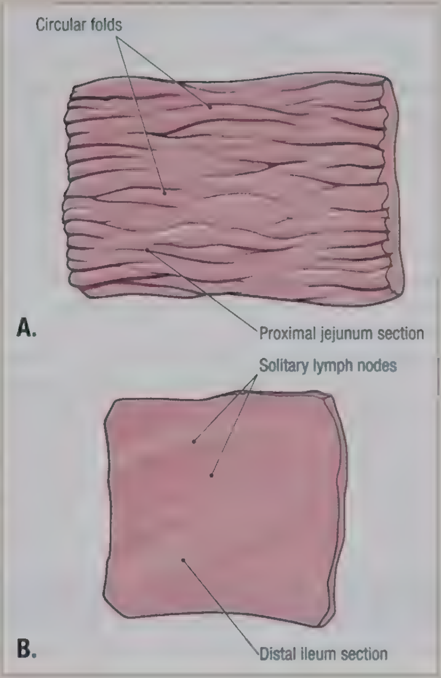

Circular folds
A.
Proximal jejunum section
Solitary lymph nodes
B.
Distal ileum section

FIGURE 4.39 ● Mucosal features of the proximal jejunum (A) and distal ileum (B). Isolated views.

13. On the inner surface of the cecum, observe the proximity of the opening of the appendix to the ileocecal orifice.
14. Observe that the inner surface of the colon consists of **semilunar folds (plicae semilunares)** between adjacent **haustra** and its mucosa is relatively smooth compared to the other parts of the gastrointestinal tract.

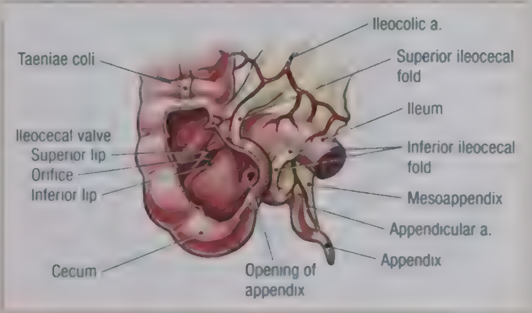

Ileocolic a.
Taeniae coli
Superior ileocecal fold
Ileum
Ileocecal valve
Superior lip
Orifice
Inferior lip
Inferior ileocecal fold
Mesoappendix
Appendicular a.
Appendix
Cecum
Opening of appendix

FIGURE 4.40 ● Ileocecal valve and blood supply to the cecum and appendix. Anterior view.

## Removal of the Gastrointestinal Tract

ATLAS 4.25, 4.67; VIDEO 4.9.3

***Dissection Note:*** If your lab dissection protocol does not call for removal of the gastrointestinal tract, skip the following dissection protocol and perform the remaining abdominal dissections with the gastrointestinal tract in situ.

1. Refer to FIGURE 4.41.
2. Inferior to the thoracic diaphragm, identify the **esophagus** and cut the anterior and posterior vagal trunks just below where they pass through the diaphragm.
3. Tie one string around the esophagus just below the point where it emerges through the **esophageal hiatus** (**String 1 location**). When securing the knot, ensure to not pull the string so tightly as to sever the esophagus superior to the string. *Note that it is not necessary to tie two strings around the esophagus because typically it is void.*
4. Transect the esophagus inferior to the location of the tied string to ensure any contents within the esophagus remain enclosed within the lumen of the organ (**Cut 1**).
5. Free the stomach by cutting through any peritoneal attachments it may still have to the posterior abdominal wall and position it to the right side of the abdominal cavity to expose the vascular branches of the celiac trunk.

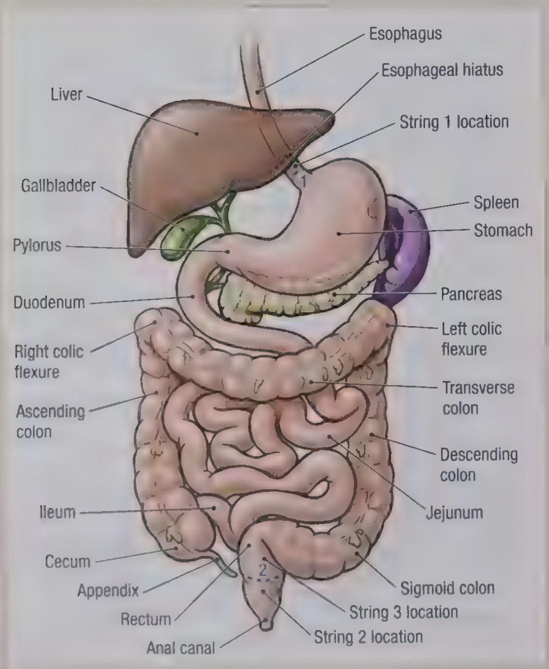


FIGURE 4.41 ● Gastrointestinal tract removal en bloc. Anterior view.

6. Transect the celiac trunk close to the abdominal aorta below the point of its trifurcation. Depending on the length of the celiac trunk, it may be possible to leave a very short stump.
7. Gently push the neck and body of the pancreas inferiorly and transect the superior mesenteric artery near the aorta, leaving a 1-cm stump.
8. Grasp the spleen and gently pull it anteriorly and medially and carefully free the splenic vessels, tail of the pancreas, and body of the pancreas from the posterior abdominal wall.
9. Insert your fingers posterior to the duodenum and free it and the head of the pancreas from the posterior abdominal wall.
10. Cut the suspensory ligament of the duodenum close to the duodenojejunal junction.
11. Cut the parietal peritoneum lateral to the ascending colon and free the ascending colon from the posterior abdominal wall.
12. Roll the ascending colon toward the midline and use your fingers to loosen its blood vessels from the posterior abdominal wall.
13. Use scissors to cut the inferior mesenteric artery near the aorta, leaving a 1-cm stump.
14. Cut the parietal peritoneum lateral to the descending colon and use your fingers to free the descending colon from the posterior abdominal wall.
15. Roll the descending colon toward the midline and use your fingers to loosen its blood vessels from the posterior abdominal wall.
16. Use your fingers to separate the fascia and peritoneum surrounding the distal end of the sigmoid colon and rectum and gently pull them away from the sacrum and left ilium.
17. Gently squeeze the rectum as far inferiorly as possible to compress any remaining internal fecal matter contents and slowly work superiorly while squeezing to create a section of the internal lumen as void as possible distal to the sigmoid colon.
18. Tie a string as far inferiorly within the pelvic cavity as you can reach around the now somewhat void rectum (**String 2 location**) and another approximately 4 cm superior to this location (**String 3 location**). Make an effort to make the knots tight but do not tighten the string so much as to sever the colon.
19. Transect the rectum **between the strings** (**Cut 2**) to ensure as little remaining fecal matter as possible enters the dissection field.
20. Cut the superior rectal artery distally as well as any fascia preventing the rectum from being elevated out of the pelvic cavity.

21. Ensure that the gastrointestinal tract, liver, pancreas, and spleen are free of any peritoneal attachments and remove them from the abdominal cavity en bloc. Support the liver while removing the abdominal contents and be careful not to twist or tear the structures in the hepatoduodenal ligament.
22. Arrange the abdominal viscera on a dissecting table or large tray in anatomical position and study the parts from the anterior view.
23. Trace the branches of the celiac trunk, superior mesenteric artery, and inferior mesenteric artery to their areas of distribution.
24. Observe the formation and termination of the hepatic portal vein, noting the differences between the branching pattern of the arteries and the veins.
25. Turn the viscera and repeat the exercise of tracing the vessels from the posterior view.

## Dissection Follow-up

1. Review the features of the gastrointestinal mucosa.
2. Compare the quantity and complexity of circular folds in the proximal and distal parts of the small intestine.
3. Compare this arrangement to the mucosal features seen in the stomach and large intestine and correlate your findings to the function of the organs dissected.
4. Recall the locations of valves in the gastrointestinal tract.
5. Store the removed abdominal viscera in a large plastic bag or return them to the abdominal cavity following your labs' dissection protocols. If a bag is used, wet the abdominal contents frequently with mold-inhibiting solution.

# POSTERIOR ABDOMINAL VISCERA

## Dissection Overview

The posterior abdominal viscera are located in the retroperitoneal space between the posterior parietal peritoneum and the muscles and bones of the posterior abdominal wall as shown in FIGURE 4.42. The retroperitoneal space contains the kidneys, ureters, suprarenal glands, aorta, inferior vena cava, and abdominal portions of the sympathetic trunks.

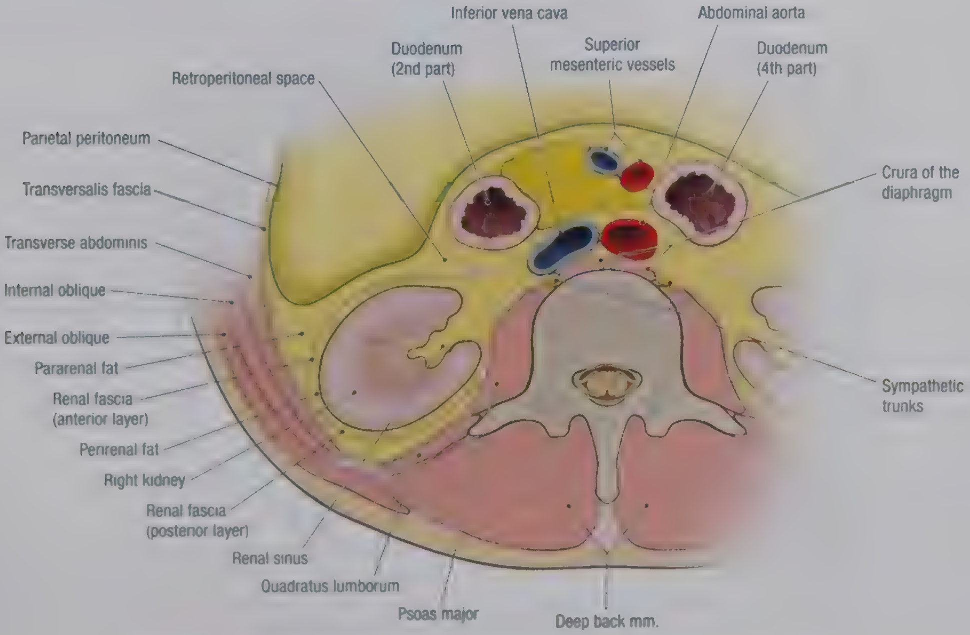

Inferior vena cava
Abdominal aorta
Duodenum (2nd part)
Superior mesenteric vessels
Duodenum (4th part)
Retroperitoneal space
Parietal peritoneum
Transversalis fascia
Transverse abdominis
Internal oblique
External oblique
Pararenal fat
Renal fascia (anterior layer)
Perirenal fat
Right kidney
Renal fascia (posterior layer)
Renal sinus
Quadratus lumborum
Psoas major
Deep back mm.
Crura of the diaphragm
Sympathetic trunks

FIGURE 4.42 ■ Transverse section of posterior abdominal wall. Inferior view.

The kidneys play key roles in the proper elimination of waste and in maintaining homeostasis in a variety of ways including blood volume and pressure regulation. The kidneys are well protected by their position within the abdomen as well as by cushioning layers of fat, an outer pararenal layer and an inner perirenal layer separated by renal fascia. The retroperitoneal position of the kidneys and their protective fatty layer is best illustrated in a transverse section.

The order of dissection will be as follows: The posterior abdominal viscera will be palpated and the parietal peritoneum removed. The renal fascia will be opened, and the kidneys and suprarenal glands will be studied. The abdominal aorta and the inferior vena cava will be dissected. The muscles of the posterior abdominal wall will be studied. The lumbar plexus of nerves will be examined. Finally, the diaphragm will be studied.

## Dissection Instructions

### Retroperitoneal Vasculature

ATLAS 4.25, 4.68, 4.76B; VIDEO 4.10.1

***Dissection Note:*** If the gastrointestinal track and associated organs were stored within the abdominal cavity, remove them from the dissection field. If necessary, use a sponge or paper towels to clean and dry the posterior abdominal wall.

1. Refer to FIGURE 4.43.
2. Identify and palpate the **abdominal aorta**. Clean the abdominal aorta inferiorly to demonstrate that it terminates at the level of L4 where it bifurcates into right and left **common iliac arteries**.
3. To the right of the abdominal aorta, identify and palpate the **inferior vena cava**. Observe that the inferior vena cava originates at the level of L5 where the right and left **common iliac veins** join.
4. Identify the **left renal vein** and use a probe to trace it from the left kidney across the midline to the inferior vena cava. Observe that it lies anterior to both renal arteries and the aorta.
5. Identify and clean the **left testicular (or ovarian) vein** draining into the left renal vein inferiorly and the **left suprarenal vein** draining into the left renal vein superiorly.
6. Identify the **left renal artery**, which lies posterior to the left renal vein. Follow the left renal artery to the hilum of the kidney and observe that it usually divides into several **segmental arteries** before it enters the kidney. *Note that accessory renal arteries are common and demonstrate one of the important processes that take place during renal development. Accessory renal arteries are an excellent example of anatomical variation.*

***Dissection Note:*** If you are dissecting a female cadaver, proceed to step 11.

7. On a male cadaver, identify and clean the **testicular artery** and **vein** beginning at the deep inguinal ring and progressing superiorly.
8. Observe that the testicular vessels cross anterior to the ureter and are quite small and delicate. Make an effort not to damage the ureter while following the vessels.
9. The **right** and **left testicular arteries** branch directly from the anterolateral surface of the aorta at about vertebral level L2, inferior to the origin of the renal arteries.
10. Observe that the **left testicular vein** drains into the left renal vein, whereas the **right testicular vein** drains directly into the inferior vena cava.

***Dissecting Note:*** If dissecting a male cadaver, proceed to the dissection sequence for the **Kidneys**.

**CLINICAL CORRELATION**

**Testicular Varicocele**

ATLAS 4.19, 4.68

Testicular varicocele occurs when the pampiniform plexus of veins becomes engorged with blood due to restriction of venous return from the testis. Testicular varicocele is more common on the left side because the left testicular vein drains into the left renal vein which is subject to compression where it passes posterior to the superior mesenteric artery.

11. In the **female cadaver**, identify and clean the **ovarian vessels**. Observe that the **ovarian arteries** originate from the aorta in a comparable location to that of the testicular arteries in the male.
12. Observe that the **left ovarian vein** drains into the left renal vein, whereas the **right ovarian vein** drains into the inferior vena cava.
13. Follow the ovarian vessels inferiorly toward the pelvic cavity until they cross the **external iliac vessels** but do not follow them into the pelvis at this time. Observe that the ovarian vessels cross anterior to the ureters along their descent.

### Kidneys

ATLAS 4.67B, 4.68, 4.71; VIDEO 4.10.2

1. Refer to FIGURE 4.43.
2. Palpate the **kidneys** and the **suprarenal (adrenal) glands** through the retroperitoneal fat between vertebral levels T12 and L3 where they lie lateral to the vertebral column.

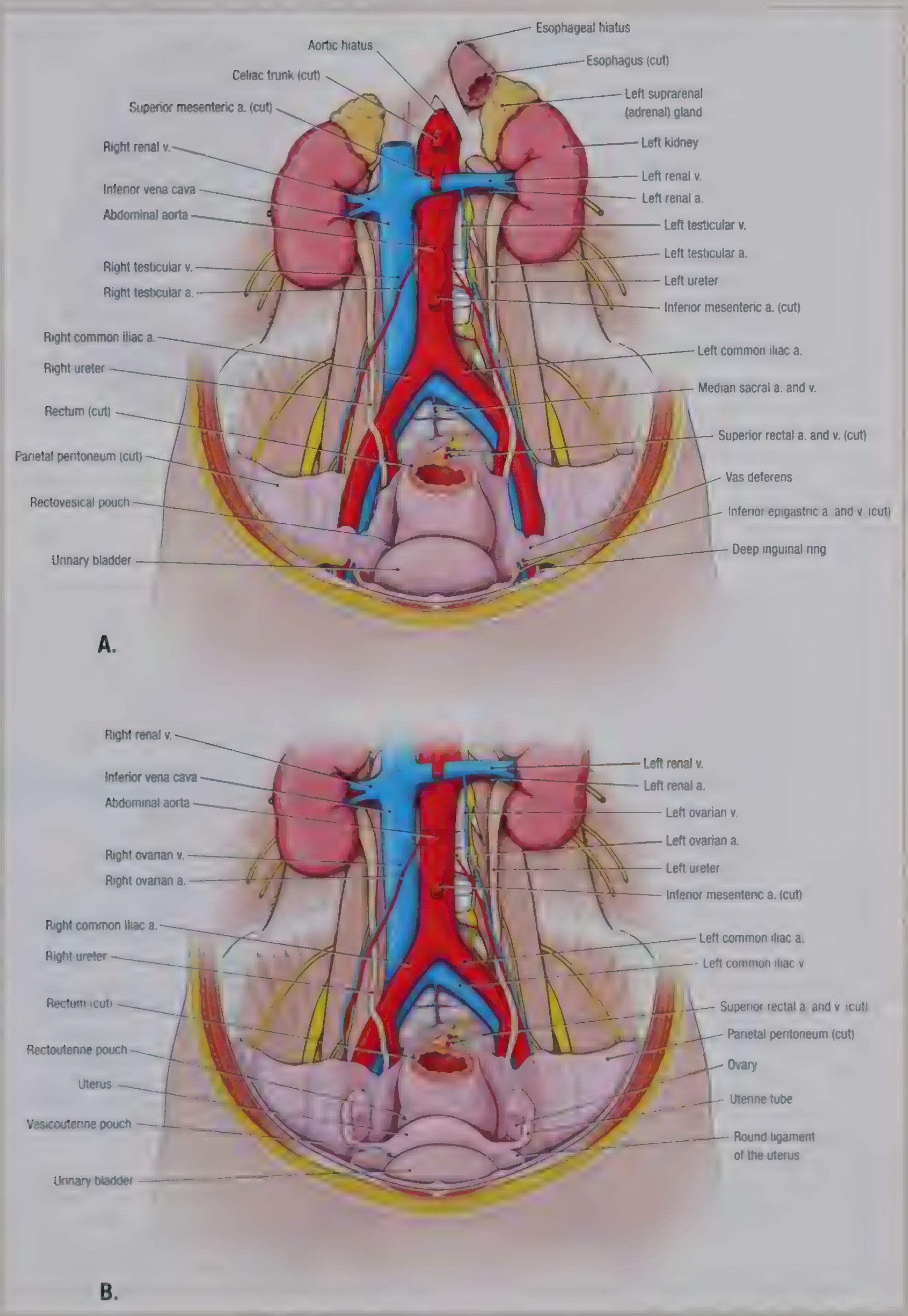

Esophageal hiatus
Aortic hiatus
Esophagus (cut)
Celiac trunk (cut)
Left suprarenal (adrenal) gland
Superior mesenteric a. (cut)
Right renal v.
Left kidney
Left renal v.
Inferior vena cava
Left renal a.
Abdominal aorta
Left testicular v.
Left testicular a.
Right testicular v.
Left ureter
Right testicular a.
Inferior mesenteric a. (cut)
Right common iliac a.
Left common iliac a.
Right ureter
Median sacral a. and v.
Rectum (cut)
Superior rectal a. and v. (cut)
Parietal peritoneum (cut)
Vas deferens
Rectovesical pouch
Inferior epigastric a. and v. (cut)
Deep inguinal ring
Urinary bladder
A.
Right renal v.
Left renal v.
Inferior vena cava
Left renal a.
Abdominal aorta
Left ovarian v.
Left ovarian a.
Right ovarian v.
Left ureter
Right ovarian a.
Inferior mesenteric a. (cut)
Right common iliac a.
Left common iliac a.
Right ureter
Left common iliac v.
Rectum (cut)
Superior rectal a. and v. (cut)
Parietal peritoneum (cut)
Rectouterine pouch
Ovary
Uterus
Uterine tube
Vesicouterine pouch
Round ligament of the uterus
Urinary bladder
B.

FIGURE 4.43 ■ Retroperitoneal vasculature and renal system. Anterior view.

3. Use blunt dissection to tear through the **renal fascia** and separate the **kidney** from the **perirenal fat** around the circumference of the kidney.
4. Carefully remove portions of the perirenal fat from the dissection field to increase visibility of the kidneys. Make an effort not to disrupt the fascia lining the posterior abdominal wall during the fat removal process.
5. Observe that the kidneys lie against the posterior abdominal wall and that the anterior surface of the kidneys face anterolaterally.
6. Observe that the **superior pole** of the kidney is separated from the suprarenal gland by a thin layer of renal fascia.
7. Use blunt dissection to identify the border between the kidney and the suprarenal gland. Be careful not to remove the suprarenal gland with the fat.
8. With the right kidney in its correct anatomical position, verify that the suprarenal gland lies superior to the kidney.
9. Verify that the right kidney, through its peritoneal covering, is in contact with the right colic flexure, the visceral surface of the liver, and the second part of the duodenum.
10. Verify that the left kidney, through its peritoneal covering, is in contact with the tail of the pancreas, the left colic flexure, the stomach, and the spleen.
11. Using the left renal artery as a hinge, turn the left kidney toward the right and observe the posterior surface of the left kidney.
12. Identify the ureter where it crosses the common iliac vessels and use blunt dissection to follow the ureter inferiorly into the pelvic cavity for a short distance.
13. Observe that the abdominal part of the ureter passes posterior to the testicular (or ovarian) vessels and crosses the anterior surface of the psoas major muscle. *Note that before the gastrointestinal tract was removed, the left ureter passed posterior to the branches of the inferior mesenteric artery.*
14. Refer to FIGURE 4.44.
15. Follow the ureter superiorly and observe that it connects to the **renal pelvis**, which exits the kidney at the **hilum**.
16. Observe that the hilum of the kidney faces anteromedially and that the lateral border faces posterolaterally.
17. Use a scalpel to divide the left kidney into anterior and posterior halves by splitting it longitudinally along its lateral border and open the two halves of the kidney like a book using the renal pelvis as the hinge.
18. On the internal aspect of the kidney, identify the **renal cortex**, the outer zone of the kidney (about one-third of its depth).

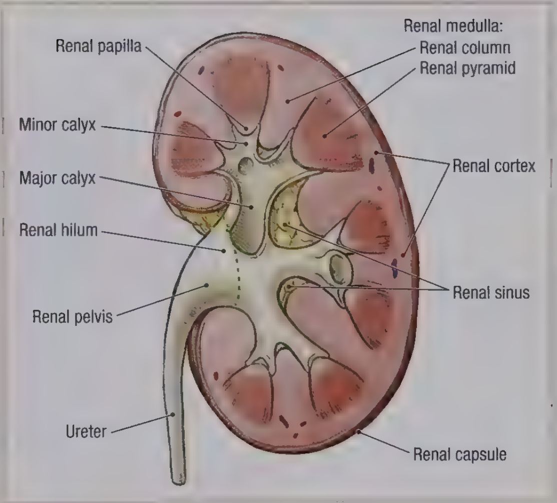


FIGURE 4.44 ■ Coronal section of the left kidney. Anterior view.

19. Observe that the cortex is surrounded by the **renal capsule**, a thin fibrous capsule firmly attached to the surface of the kidney.
20. Deep to the renal cortex, identify the **renal medulla**, the inner zone of the kidney (about two-thirds of its depth). Observe that the renal medulla consists of **renal pyramids** separated by **renal columns**.

### CLINICAL CORRELATION

### Kidney Stones

ATLAS 4.70

Kidney stones (renal calculi) may form in the calyces and renal pelvis. Small kidney stones may spontaneously pass through the ureter into the bladder. Larger kidney stones may lodge at one of three natural constrictions of the ureter: (1) the uretopelvic junction, where the renal pelvis becomes constricted to form the ureter, (2) where the ureter crosses the pelvic brim, and (3) at the entrance of the ureter into the urinary bladder. Kidney stones are often excruciatingly painful until they pass (naturally) or are treated (via invasive or non invasive techniques).

21. At the apex of the renal pyramids, identify the **renal papilla** that projects into a **minor calyx**. Observe that the **minor calyx** is a cup-like chamber that is the beginning of the extrarenal duct system.
22. Observe that several minor calyces combine to form a **major calyx**, which drains into the **renal pelvis**, the funnel-like proximal end of the ureter that begins

within the **renal sinus** and emerges from the renal hilum. *Note that the **renal sinus** is the space within the kidney occupied by the renal pelvis, calices, vessels, nerves, and fat.*

23. Follow the renal pelvis to the **ureter**, the muscular duct that carries urine from the kidney to the urinary bladder.
24. Return the left kidney to its correct anatomical position.

## Suprarenal (Adrenal) Glands

ATLAS 4.70; VIDEO 4.10.3

***Dissection Note:*** The suprarenal glands are fragile and may be easily torn or mistaken for adipose tissue, so care must be taken when dissecting them. The suprarenal glands are endocrine glands and have a copious blood supply from vessels that are similarly delicate and easy to tear.

1. Refer to FIGURE 4.45.
2. Palpate the suprarenal glands within the perirenal fat. *Note that often the boundaries of the glands are difficult to differentiate from the surrounding fat, therefore use the vessels in the region to help delineate the border.*
3. Observe that the **right suprarenal gland** is commonly triangular in shape and that a part of it lies posterior to the inferior vena cava.
4. Observe that the **left suprarenal gland** is commonly semilunar in shape and more exposed.

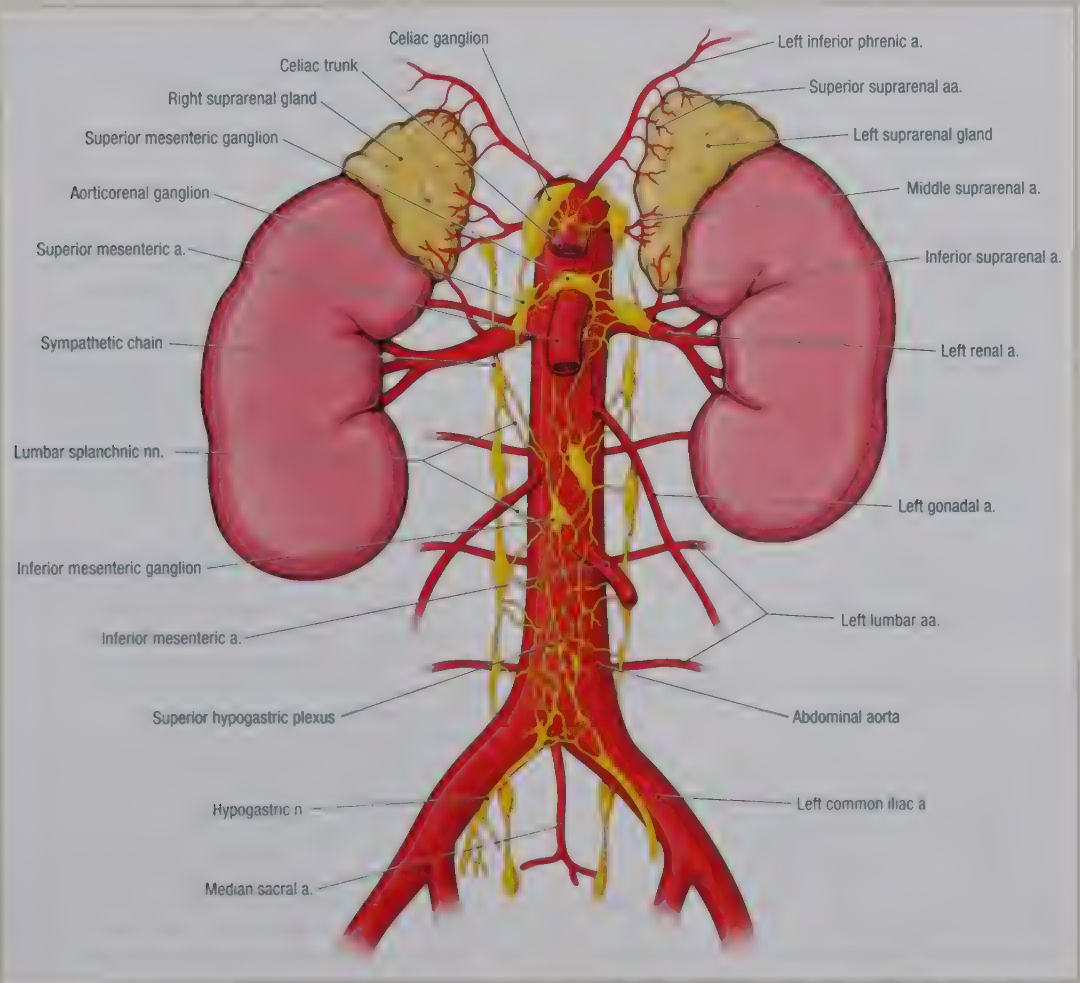

Celiac ganglion
Celiac trunk
Right suprarenal gland
Superior mesenteric ganglion
Aorticorenal ganglion
Superior mesenteric a.
Sympathetic chain
Lumbar splanchnic nn.
Inferior mesenteric ganglion
Inferior mesenteric a.
Superior hypogastric plexus
Hypogastric n
Median sacral a.
Left inferior phrenic a.
Superior suprarenal aa.
Left suprarenal gland
Middle suprarenal a.
Inferior suprarenal a.
Left renal a.
Left gonadal a.
Left lumbar aa.
Abdominal aorta
Left common iliac a

FIGURE 4.45 ■ Paired and unpaired branches of the abdominal aorta and autonomics of the lumbar region. Anterior view.

CLINICAL CORRELATION

### Suprarenal Gland Development

ATLAS 4.70

The kidneys and suprarenal glands have different embryonic origins, thus if the kidney fails to ascend to its normal position during development, the suprarenal gland still develops in its normal position lateral to the celiac trunk. In renal transplantation the suprarenal glands may be separated from the deficient kidney at the relatively weak septum of renal fascia between the organs. As the natal kidney may still have minimal function, and removal may damage the suprarenal glands, it may however be left in place. To facilitate implantation the donor kidney is typically placed in the iliac fossa with the new renal vessels connecting to the external iliac vessels.

5. Observe that each suprarenal gland receives multiple arteries from various sources and that care must be taken to preserve these small delicate vessels.
6. Identify the **inferior suprarenal artery** arising from the renal artery. To isolate the small delicate arteries, gently push the probe through the fat parallel to the expected direction of the vessels.
7. Using a similar technique with the probe, carefully identify the **superior suprarenal artery** arising from the inferior phrenic artery and the **middle suprarenal artery** arising from the aorta near the celiac trunk.
8. Remove the remaining perirenal fat from the region noting the presence of a vast collection of small nerve fibers paralleling the vessels.
9. Observe that the left suprarenal vein empties into the left renal vein and that the right suprarenal vein drains directly into the inferior vena cava.
10. The suprarenal glands receive numerous sympathetic nerve fibers from the surrounding ganglia. It is not necessary to try to identify the sympathetic innervation of the adrenal glands.

## Abdominal Aorta and Inferior Vena Cava

ATLAS 4.68, 4.80; VIDEO 4.10.4

1. Refer to FIGURE 4.45.
2. Identify the **abdominal aorta** and observe that it begins at vertebral level T12 as the continuation of the thoracic aorta inferior to the diaphragm and that it ends by bifurcating at vertebral level L4 to form the **right** and **left common iliac arteries**.
3. Observe that the abdominal aorta has three types of branches: unpaired visceral, paired visceral, and paired somatic.
4. Identify the unpaired visceral arteries arising from the midline to the gastrointestinal tract: the **celiac trunk**, the **superior mesenteric artery**, and the **inferior mesenteric artery**.
5. Identify the paired visceral arteries coursing to the three paired abdominal organs: the **middle suprarenal arteries**, the **renal arteries**, and the **gonadal** (testicular or ovarian) **arteries**.
6. Identify the paired somatic arteries to the abdominal wall: the **inferior phrenic arteries** and the **lumbar arteries**.
7. Identify at least one of four pairs of **lumbar arteries** and observe that the right lumbar arteries cross the lumbar vertebral bodies and pass posterior to the inferior vena cava. *Note that on both sides, the lumbar arteries pass deep to the psoas major muscles.*
8. On the inferior surface of the diaphragm, clean the **inferior phrenic arteries** and trace them back to their point of origin from the aorta near the aortic hiatus. Recall that these arteries give rise to superior suprarenal arteries.
9. At the termination of the abdominal aorta, identify and clean the proximal portion of the **common iliac arteries** at L4. The common iliac arteries supply blood to the pelvis and lower limbs and will be dissected in more detail with the pelvis.
10. Observe that **preaortic ganglia** surround the abdominal aorta and its visceral branches forming a complex network of autonomic nerves.
11. Make an effort to identify the **celiac**, **superior mesenteric**, **aorticorenal**, and **inferior mesenteric ganglia**.
12. Observe that connections from the preaortic ganglia extend along the lateral aspect of the aorta inferiorly in the **hypogastric plexuses**, which carry autonomic information to and from the pelvis via the **hypogastric nerves**.
13. Refer back to FIGURE 4.43.
14. Identify and clean the **inferior vena cava** beginning at the L5 vertebral level as well as its major tributaries, the **right** and **left common iliac veins**. Recall that the inferior vena cava ends at the T8 vertebral level by passing through the diaphragm to empty into the right atrium.
15. Observe that the inferior vena cava receives venous drainage from the paired abdominal organs (**renal veins**, suprarenal veins, **gonadal** [testicular or ovarian] **veins**) either directly (right side) or indirectly (left side). *Note that the inferior vena cava has no unpaired tributaries from the gastrointestinal tract because the hepatic portal system collects all the blood from the gastrointestinal tract and drains into the liver. From there, the hepatic veins drain the liver into the inferior vena cava.*
16. Identify and clean the paired veins from the abdominal wall (lumbar veins and inferior phrenic veins), which drain into the inferior vena cava.

## Dissection Follow-up

1. Review the relationships of each kidney to the surrounding structures.
2. Trace the path taken by a drop of urine from the renal papilla through the ureter to the level of the pelvic brim, noting the points of possible constriction.
3. Review the shape, position, relationships, arterial supply, and venous drainage of each suprarenal gland.
4. Review the branches of the abdominal aorta.
5. Review the location of the autonomic ganglia in the lumbar region.
6. Review the tributaries of the inferior vena cava.
7. Replace the kidneys and other abdominal contents in their correct anatomical positions.

# POSTERIOR ABDOMINAL WALL

## Dissection Overview

The posterior abdominal wall is composed of the vertebral column, muscles that move the vertebral column, muscles that move the lower limbs, and the diaphragm. The nerves of the posterior abdominal wall arise from the anterior rami of spinal nerves T12–L4. The lumbar plexus (L1–L4) is formed within the psoas major muscle and its branches can be seen as they emerge from the lateral border of the psoas. The nerves that supply the abdominal wall and the lumbar plexus of nerves that innervate the lower limb will be dissected with the posterior abdominal wall.

The order of dissection will be as follows: Muscles that form the posterior abdominal wall will be dissected. The branches of the lumbar plexus will be studied. The abdominal part of the sympathetic trunk will be studied.

## Dissection Instructions

### Muscles of the Posterior Abdominal Wall

ATLAS 4.77; VIDEO 4.11.1

***Dissection Note:*** While identifying the muscles of the posterior abdominal wall, *do not* yet remove the overlying fascia or clean the muscles because the nerves in the region may be damaged.

1. Refer to FIGURE 4.46.
2. Move each respective kidney and suprarenal gland toward the midline, making sure you do not cut their associated vessels, and remove the remaining fat and renal fascia from the posterior abdominal wall on each side.
3. Identify the **psoas major muscle** on the lateral aspects of the lumbar vertebrae.
4. Look for the **psoas minor muscle** and observe that it has a long flat tendon passing down the anterior surface of the psoas major muscle. *Note that the psoas minor muscle is absent entirely in some individuals and may be present on only one side of the body in others.*
5. Identify the **iliacus muscle** lateral to the psoas major muscle in the depression of the iliac fossa. *Note that the iliacus and psoas major muscles merge deep to the inguinal ligament to form a functional unit collectively called the* ***iliopsoas muscle****.*
6. Identify the **quadratus lumborum muscle** lateral to the psoas major muscle but superior to the iliac crest.
7. Review the attachments, actions, and innervations of the psoas major, psoas minor, iliacus, and quadratus lumborum muscles (see **TABLE 4.2**).
8. Identify the **transversus abdominis muscle** and recall that it is one of the anterolateral abdominal wall muscles dissected at the beginning of this unit.
9. Observe that the transversus abdominis muscle lies posterior to the quadratus lumborum muscle.
10. Verify that the posterior surface of each kidney is related, through the renal fat and fascia, to the diaphragm, psoas major muscle, quadratus lumborum muscle, and transversus abdominis muscle.
11. Observe that the superior pole of the right kidney is near the 12th rib and that the superior pole of the left kidney is slightly higher, near the 11th rib.

### Lumbar Plexus

ATLAS 4.77, 4.78; VIDEO 4.11.2

***Dissection Note:*** The branching pattern of the nerves of the lumbar plexus varies somewhat between individuals. Use the peripheral relationships of the nerves (their region of distribution or a point of exit from the abdominal cavity) for positive identification.

1. Refer to FIGURE 4.46.
2. Identify the **genitofemoral nerve** on the anterior surface of the psoas major muscle. Observe that the genitofemoral nerve divides into **genital** and **femoral branches** superior to the inguinal ligament.

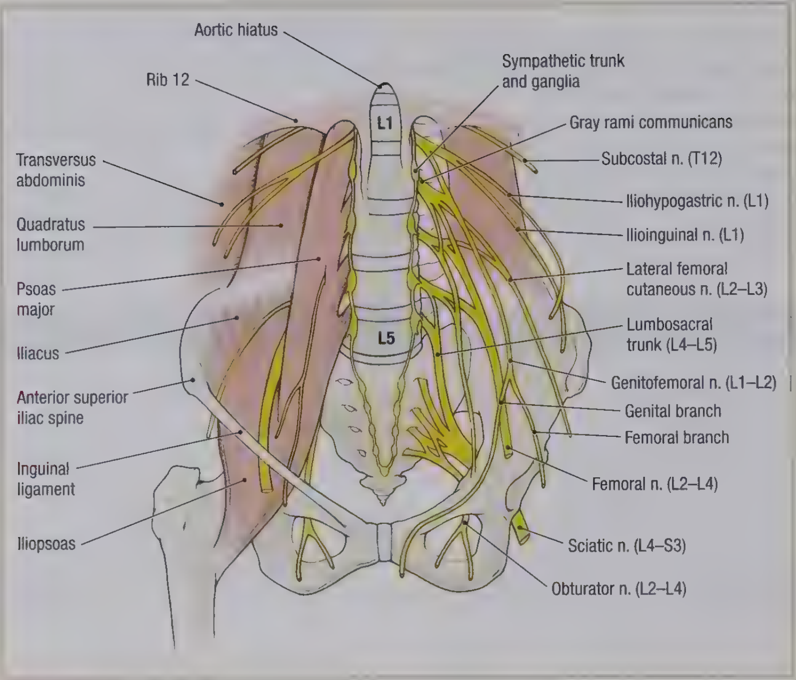

Aortic hiatus
Rib 12
Transversus abdominis
Quadratus lumborum
Psoas major
Iliacus
Anterior superior iliac spine
Inguinal ligament
Iliopsoas
L1
L5
Sympathetic trunk and ganglia
Gray rami communicans
Subcostal n. (T12)
Iliohypogastric n. (L1)
Ilioinguinal n. (L1)
Lateral femoral cutaneous n. (L2–L3)
Lumbosacral trunk (L4–L5)
Genitofemoral n. (L1–L2)
Genital branch
Femoral branch
Femoral n. (L2–L4)
Sciatic n. (L4–S3)
Obturator n. (L2–L4)

FIGURE 4.46 ■ Lumbar plexus and muscles of the posterior abdominal wall. Anterior view.

3. Identify the **genital branch of the genitofemoral nerve** and observe that it passes through the deep inguinal to enter the inguinal canal. *Note that the genital branch is the motor nerve to the cremaster muscle, the thin muscle responsible for elevation of the testis.*
4. Identify the **femoral branch of the genitofemoral nerve** and observe that it passes deep to the inguinal ligament on the anterior surface of the external iliac artery. *Note that the femoral branch supplies a small area of skin inferior and medial to the inguinal ligament.*
5. Use blunt dissection to remove the extraperitoneal fascia from the posterior abdominal wall lateral to the psoas major muscle. The branches of the lumbar plexus are embedded in the extraperitoneal fascia and care must be taken not to damage them.
6. To find the **subcostal nerve,** palpate rib 12 and look for the subcostal nerve about 1 cm inferior and parallel to it.
7. Find the **iliohypogastric** and **ilioinguinal nerves,** which descend steeply across the anterior surface of the quadratus lumborum muscle. Frequently, these two nerves arise from a common trunk with the iliohypogastric nerve located more superiorly and do not separate until they reach the transversus abdominis muscle.
8. To positively identify the ilioinguinal nerve, follow it through the anterolateral abdominal wall into the inguinal canal where it then exits via the superficial inguinal ring.
9. Identify the **lateral cutaneous nerve of the thigh** where it passes deep to the inguinal ligament near the ASIS. The lateral cutaneous nerve of the thigh supplies the skin on the lateral aspect of the thigh.
10. Identify the **femoral nerve** on the lateral side of the psoas major muscle in the groove between the psoas major and iliacus muscles. The femoral nerve innervates the iliacus muscle and passes deep to the inguinal ligament to provide motor and sensory branches to the anterior thigh.
11. Identify the **obturator nerve** medial and parallel to the psoas major muscle within the lateral aspect of the pelvic cavity deep to the common iliac vessels. The obturator nerve supplies motor and sensory innervation to the medial thigh.
12. Identify the **lumbosacral trunk** medial to the obturator nerve. Observe that the lumbosacral trunk is a large nerve formed by contributions from the anterior ramus of L4 and all of the anterior ramus of L5. The lumbosacral trunk passes into the pelvis to join the sacral plexus and should be followed only a short distance at this time.

13. On the left side of the abdominal cavity, follow each nerve of the lumbar plexus proximally into the psoas major muscle and observe that each branch of the lumbar plexus passes through the psoas major muscle at a different depth.
14. Clean the posterior abdominal wall to clearly display each nerve of the lumbar plexus as well as the superior extent of each muscle passing deep to the diaphragm.

### Abdominal Part of the Sympathetic Trunk

ATLAS 4.78, 4.81; VIDEO 4.11.3

1. Refer to FIGURE 4.46.
2. On the left side of the posterior abdominal wall, identify and clean the **sympathetic trunk**. Observe that the sympathetic trunk lies on the lumbar vertebral bodies between the crus of the diaphragm and the psoas major muscle.
3. Identify **lumbar splanchnic nerves** that pass anteriorly from the lumbar sympathetic ganglia to the aortic autonomic nerve plexus.
4. Beginning at the genitofemoral nerve, remove the psoas major muscle piece by piece, on one side only, to fully expose the lumbar plexus. Pay attention not to damage the lumbar vessels or the sympathetic trunk.
5. Cut and remove the psoas major muscle to a point just proximal to its passage deep to the inguinal ligament and place its pieces in the tissue container.
6. With the psoas major muscle removed, examine the point of exit of each spinal nerve from its intervertebral foramen and verify the spinal level contributions to each named nerve (e.g., femoral nerve—L2, L3, L4).
7. Identify rami communicantes that pass posteriorly from the sympathetic ganglia to the lumbar anterior rami. *Note that the gray rami of the lower lumbar region are the longest in the body because the sympathetic trunk crosses the anterolateral surface of the lumbar vertebral bodies.*
8. Observe that the rami communicantes lie against the lateral surface of the vertebral bodies. To assist finding the rami communicantes, clean and follow the lumbar arteries from their origin off the abdominal aorta and observe the relationship of the arteries, veins, and nerves in the lumbar region.
9. Review the autonomic nerve supply of the abdominal viscera.

## Dissection Follow-up

1. Review the proximal and distal attachments as well as the action of each of the muscles of the posterior abdominal wall in **TABLE 4.2**.
2. Review the three muscles that form the anterolateral abdominal wall (external oblique, internal oblique, and transversus abdominis).
3. Follow each branch of the lumbar plexus peripherally. Review the region of innervation of each of these nerves.
4. Review the abdominal part of the sympathetic trunk, the lumbar splanchnic nerves, and rami communicantes (both gray and white).
5. Replace the abdominal contents in their correct anatomical positions.

**TABLE 4.2 | Muscles of the Posterior Abdominal Wall**

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Psoas major | Lumbar vertebrae (bodies, intervertebral discs, and transverse processes) | Lesser trochanter of the femur | Flexes the thigh and extends the vertebral column | L1–L4 (anterior rami) |
| Psoas minor | Lateral surface of T12 and L1 | Iliopubic eminence and arcuate line of the ilium | Tilts pelvis posteriorly | L1–L2 (anterior rami) |
| Iliacus | Iliac fossa | Lesser trochanter of the femur | Flexes the thigh | Femoral n. |
| Quadratus lumborum | 12th rib and lumbar transverse processes | Iliolumbar ligament and iliac crest | Flexes vertebral column laterally and anchors the rib cage during respiration | T12–L4 (anterior rami) |

Abbreviation: n., nerve.

# DIAPHRAGM

## Dissection Overview

The diaphragm forms the roof of the abdominal cavity and the floor of the thoracic cavity. The diaphragm is the principal muscle of respiration and has a right half and a left half (the hemidiaphragms). Openings through the diaphragm allow passage of structures between the thoracic cavity and abdominal cavities while maintaining respiratory function. From superior to inferior these openings are the caval foramen, the esophageal hiatus, and the aortic hiatus.

The order of dissection will be as follows: The parts of the diaphragm will be identified. The phrenic nerve will be reviewed. The greater splanchnic nerves that pass through the diaphragm will be studied.

## Dissection Instructions

### Diaphragm

ATLAS 4.79, 4.81; VIDEO 4.12.1

***Dissection Note:*** If the ribs were previously cut, separate them to either side to increase visibility and ease of access to the diaphragm. If the ribs were not yet cut, consider separating them at this following dissection sequence entitled **Reflection of the Diaphragm** before proceeding.

1. Refer to FIGURE 4.47.
2. Use blunt dissection to strip the parietal peritoneum and connective tissue off the abdominal surface of the diaphragm sparing the inferior phrenic vessels.
3. Identify the **central tendon of the diaphragm**, the aponeurotic center of the diaphragm, and distal attachment of all of its muscular parts. Recall that the pericardial sac fused with the superior aspect of the central tendon.

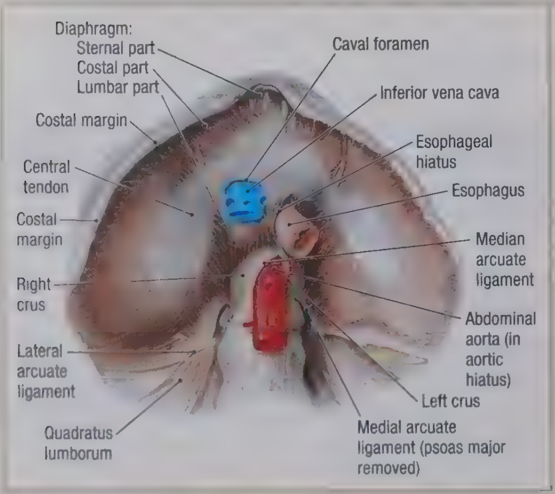


FIGURE 4.47 ● Openings of the respiratory diaphragm. Inferior view.

4. The muscular portion of the diaphragm can be subdivided into sternal, costal, and lumbar parts. Identify the **sternal part** of the diaphragm: two small bundles of muscle fibers attaching to the posterior surface of the xiphoid process.
5. Identify the **costal part** of the diaphragm, where the muscle fibers attach to the inferior six ribs and their costal cartilages.
6. Identify the **lumbar part** of the diaphragm formed by two crura (right and left) and the muscle fibers that arise from the medial and lateral arcuate ligaments.
7. Identify the **right crus** of the diaphragm and observe that it has attachments to the bodies of vertebrae L1–L3 and wraps around the esophagus to form the **esophageal hiatus**.
8. Identify the **left crus** of the diaphragm and observe that it has attachments to the bodies of vertebrae L1 and L2.
9. Identify the **arcuate ligaments**, thickenings of transversalis fascia that serve as proximal attachments for some of the muscle fibers of the diaphragm.
10. Identify the **lateral arcuate ligament** bridging the anterior surface of the quadratus lumborum muscle, the **medial arcuate ligament** bridging the anterior surface of the psoas major muscle, and the **median arcuate ligament** (unpaired) bridging the anterior surface of the aorta at the aortic hiatus.
11. Identify the **caval (vena caval) foramen** passing through the central tendon at vertebral level T8. Observe that the caval foramen only allows passage of the **inferior vena cava** through the diaphragm.
12. Identify the **esophageal hiatus** passing through the right crus at vertebral level T10 and observe that the **esophagus** and vagal trunks pass through this opening.
13. Identify the **aortic hiatus** passing posterior to the diaphragm at vertebral level T12.
14. Observe that the aortic hiatus transmits the **aorta**, the azygos and hemiazygos veins, and the thoracic duct.
15. Observe that the sympathetic trunk passes through the diaphragm between the muscle fibers and the posterior abdominal wall musculature.

16. Within the thorax, identify the right and left phrenic nerves and recall that they provide motor innervation to the right and left hemidiaphragms, respectively, most of the sensory innervation to the diaphragmatic (parietal) peritoneum inferiorly and diaphragmatic (parietal) pleura superiorly, the mediastinal pleura, and the fibrous pericardium and parietal layer of serous pericardium. *Note that the pleural and peritoneal coverings of the peripheral part of the diaphragm receive sensory fibers from the lower intercostal nerves (T5–T11) and the subcostal nerve.*
17. To increase mobility of the diaphragm, cut the right phrenic nerve 4 cm proximal to the superior surface of the diaphragm and push the right hemidiaphragm inferiorly.
18. Clean and follow the azygos vein and the thoracic duct inferiorly toward where they pass through the aortic hiatus. To verify the opening in the diaphragm that the azygos vein and thoracic duct pass through, gently push a probe through the aortic hiatus parallel to the aorta and note the proximity of these structures.
19. Identify the greater splanchnic nerve in the right thorax and observe that it arises from vertebral levels T5–T9. Follow the greater splanchnic nerve inferiorly and verify that it penetrates the crus of the diaphragm to enter the abdominal cavity. *Note that the main portion of the greater splanchnic nerve distributes to the celiac ganglion where its sympathetic axons will synapse.*
20. Inferior to the greater splanchnic nerve, make an effort to identify and clean the lesser splanchnic nerve arising from vertebral levels T10–T11. *Note that the least splanchnic nerve is difficult to identify because it arises from vertebral level T12 deep to the posterior attachments of the diaphragm.*
21. Find the celiac ganglia, if they have not been previously removed, on the left and right sides of the celiac trunk near its origin from the aorta and observe the connection the thoracic splanchnic nerves.
22. Near the celiac ganglia, make an effort to locate the cysterna chyli (chyle cistern), a thin walled lymphatic structure at the inferior end of the thoracic duct.

**CLINICAL CORRELATION**

**Diaphragmatic Hernias**

ATLAS 4.79

Herniation of either abdominal or thoracic contents may occur through or around the diaphragm due to changes in intra-abdominal pressure, trauma, or developmental anomalies. A hiatal hernia allows passage of the stomach through the esophageal hiatus up into the thoracic cavity and, although a congenital malformation, may occur posterior to or through the diaphragm, a possibly life-threatening condition.

Pain from the diaphragm is carried by the phrenic nerves (C3–C5), and referred to the region of the shoulder via the supraclavicular cutaneous nerves arising from the same vertebral levels. The diaphragm can be paralyzed in cases of midcervical spinal cord injuries, but it is spared in low-cervical spinal cord injuries. A paralyzed hemidiaphragm cannot contract (descend), so it will be positioned higher than normal in the thorax on a chest radiograph.

## Dissection Follow-up

1. Review the attachments of the diaphragm to the skeleton of the thoracic wall.
2. Trace the course of the thoracic aorta as it passes through the aortic hiatus to become the abdominal aorta.
3. Review the course of the esophagus and vagal trunks through the esophageal hiatus.
4. Recall the position of the heart on the superior surface of the diaphragm and review the course of the inferior vena cava to the right atrium through the liver and diaphragm.
5. Observe that the thoracic duct passes through the aortic hiatus and that the splanchnic nerves (greater, lesser, and least) penetrate the crura.
6. Replace the abdominal contents in their correct anatomical positions.

## CHAPTER 5

# The Pelvis and Perineum

**REFERENCES**

| | |
|---|---|
| ATLAS = *Grant's Atlas of Anatomy*, 15th ed., figure number | VIDEO = *Grant's Dissection Videos*, video sequence number |

The pelvis is the area of transition between the trunk and the lower limbs. The bony pelvis serves as the foundation for the pelvic region, provides protection for pelvic organs, and acts as a strong support for the vertebral column on the lower limbs. The pelvic cavity may be subdivided into a greater (false) pelvis, the portion continuous with the abdominal cavity, and a lesser (true) pelvis, the portion enclosed by the bony pelvis, with the transition occurring at the plane of the pelvic inlet as shown in FIGURE 5.1.

The pelvic cavity contains the rectum, the urinary bladder, and the internal genitalia. The perineum is the region of the trunk located between the thighs and separated from the pelvic cavity by the pelvic diaphragm. The perineum contains the anal canal, the urethra, and the external genitalia (penis and scrotum in the male and vulva in the female).

This chapter begins with the dissection of structures in the anal triangle common to both sexes. Dissection of internal and external genitalia is divided into two sections: one for male cadavers and one for female cadavers. Students are expected to learn the anatomy of both the male and female pelvis and perineum; therefore, each dissection team should partner with another team dissecting a cadaver of the opposite sex.

### CLINICAL CORRELATIONS

During the course of your dissection protocol, you may encounter anatomical variations, clinical conditions, disease processes, or medical devices in your cadaveric donor. The following select clinical correlations will be described in more detail throughout this chapter.

**The Pelvis**

1. Sex and Gender, see the **Skeletal Anatomy** sequence. ATLAS 4.17
2. Vasectomy, see the **Spermatic Cord** sequence. ATLAS 5.22B
3. Lymphatic Drainage of the Testis, see the **Testis** sequence. ATLAS 4.20C
4. Rupture of the Male Urethra, see the **Male Superficial Perineal Pouch** sequence. ATLAS 5.51B, 5.52B
5. Circumcision, see the **Penis** sequence. ATLAS 5.54
6. Urinary Bladder and Pelvic Peritoneum, see the **Male Pelvic Peritoneum** sequence. ATLAS 5.15, 5.23
7. Benign Prostatic Hypertrophy and Digital Rectal Examination, see the **Male Rectum and Anal Canal** sequence. ATLAS 5.24C
8. Hypogastric Nerve Damage, see the **Male Pelvic Nerves** sequence. ATLAS 5.13, 5.29B
9. Lymphatic Drainage of the Labium Majus, see the **Labium Majus (pl. Labia Majora)** sequence. ATLAS 5.39
10. Obstetric Considerations, see the **Female Deep Perineal Pouch** sequence. ATLAS 5.30E, 5.30G, 5.59
11. The Uterus, see the **Female Pelvic Peritoneum** sequence. ATLAS 5.30, 5.31, 5.36
12. Hemorrhoids, see the **Female Rectum and Anal Canal** sequence. ATLAS 5.18D
13. Uterine Artery and Hysterectomy, see the **Female Pelvic Blood Vessels** sequence. ATLAS 5.33C

# ANAL TRIANGLE

## Dissection Overview

The perineum is a diamond-shaped area, inferior to the pelvic diaphragm, between the thighs. The perineum is commonly divided into two triangles for descriptive purposes: the urogenital triangle and the anal triangle. At the outset of dissection, it is important to understand that these two triangles are not in the same plane and that the pelvic diaphragm separates the pelvic cavity from the perineum.

The ischioanal (ischiorectal) fossa is a wedge-shaped area on either side of the anus within the anal triangle. The apex of the wedge is directed superiorly toward the coccyx, and the base is beneath the skin. The ischioanal fossa is filled with loose fat to accommodate physical changes within the pelvis such as distension of the anal canal during the passage of feces or movement of the fetus during childbirth.

The order of dissection will be as follows: The skeleton of the male and female pelvis will be reviewed. The skin of the gluteal region will be removed, and the gluteus maximus muscle will be retracted. The nerves and vessels of the ischioanal fossa will be dissected. The fat will be removed from the ischioanal fossa to reveal the inferior surface of the pelvic diaphragm.

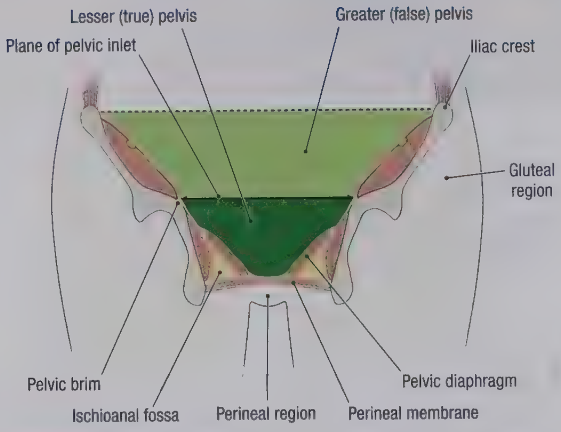


FIGURE 5.1 ● Coronal (frontal) section through the pelvis. Anterior view.

### Skeletal Anatomy

Refer to an articulated bony pelvis and identify the following skeletal features.

#### *Skeleton of the Pelvis*

ATLAS 5.3, 5.8B

1. Refer to FIGURE 5.2.
2. Observe that the bony **pelvis** is formed by two **hip bones (os coxae)** joined posteriorly to the **sacrum**.
3. Inferior to the sacrum, identify the fused coccygeal vertebrae making up the **coccyx** and note that they do not articulate with the hip bones.
4. Identify the roughened area of the **ischial tuberosity** on the lowest point of the bony pelvis. *Note that the ischial tuberosity is the area of attachment for the hamstrings as well as the **sacrotuberous ligament**.*
5. Identify the iliac crest of the ilium, the highest point of the bony pelvis.
6. Follow the iliac crest posteriorly and identify the **posterior superior iliac spine (PSIS)**.
7. Compare a male and female pelvis and observe that the distance between the ischial tuberosities is greater in the female than the male.
8. From a posterior perspective, identify the **ischial spine** of the ischium and observe that this bony projection is directed toward the sacrum.
9. Observe that the ischial spine separates the **greater sciatic notch** from the **lesser sciatic notch** and serves as point of attachment for the **sacrospinous ligament**.
10. Compare a male and female pelvis and observe that the distance between the ischial spines is greater in the female than the male.
11. On the sacrum, identify the **posterior sacral foramina** and observe that these foramina connect to the **sacral canal** and are continuous with the **anterior sacral foramina**.
12. On an articulated pelvis, observe that the **sacroiliac articulation** is strengthened by both a **posterior sacroiliac ligament** and an **anterior sacroiliac ligament**. *Note that the sacroiliac articulation is a synovial joint between the auricular surfaces of the sacrum and the ilium.*
13. On an articulated pelvis, observe that the **iliolumbar ligament** strengthens the articulation at the **lumbosacral joint** and that the **supraspinous ligament** courses along the spinous processes of the lumbar vertebrae to the **median sacral crest**.

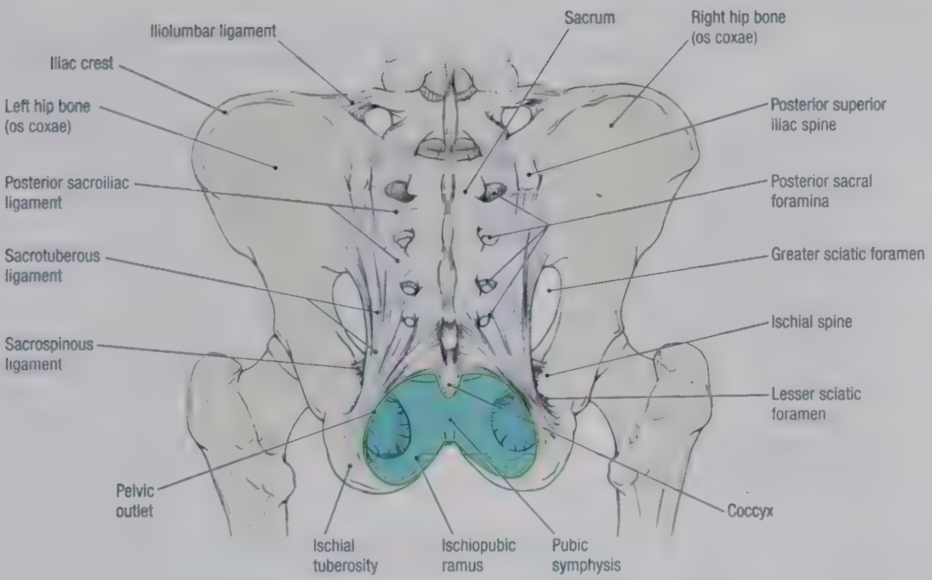

Iliolumbar ligament
Iliac crest
Left hip bone (os coxae)
Posterior sacroiliac ligament
Sacrotuberous ligament
Sacrospinous ligament
Pelvic outlet
Ischial tuberosity
Ischiopubic ramus
Pubic symphysis
Coccyx
Sacrum
Right hip bone (os coxae)
Posterior superior iliac spine
Posterior sacral foramina
Greater sciatic foramen
Ischial spine
Lesser sciatic foramen

FIGURE 5.2 ■ Bones and ligaments of the pelvis. Posterior view.

14. Identify the **pelvic outlet** and observe that it is bound anteriorly by the **inferior margin of the pubic symphysis**; posteriorly by the **tip of the coccyx**; and laterally by the **ischiopubic rami**, the **ischial tuberosities**, and the **sacrotuberous ligaments**.
15. Compare a male and female pelvis and observe that the pelvic outlet is larger and more rounded in the female than the male.

**CLINICAL CORRELATION**

### Sex and Gender

ATLAS 4.17

The sex of an individual is determined by chromosomes and gonad development and designated at birth. For descriptive purposes in this text whenever male and female terms are used, it is referencing congenital- or birth-assigned sex and the associated physical characteristics correlating to each. As such, the male gonad is the testis, whereas the female gonad is the ovary. Although chromosomal or developmental variations may occur, for our purposes of anatomical study through dissection, the male and female binary designation will be assumed.

The gender of an individual relates to their sense of self, identity, representation, and role in society, and it is important to note that this is not a binary category of distinction. An individual may identify as male or female as they associate with either masculine or feminine traits and characteristics or may better associate as nonbinary, third gender, androgynous, gender fluid, genderqueer, or transgender. Youths, adolescents, or adults may undergo gender dysphoria (GD), a distress associated with their birth-assigned sex not matching their gender identity, a condition particularly prevalent in the transgender community.

## Surface Anatomy

The surface anatomy of the pelvis and perineum may be studied on a cadaver, although fixation of tissue during embalming may make it difficult to distinguish bone from well-preserved soft tissues in some specimens.

### *Anal Triangle*

ATLAS 5.45A, 5.46B, 5.62B

1. Refer to FIGURE 5.3.
2. With the cadaver lying in the prone position, palpate tip of **coccyx** in the midline posteriorly.

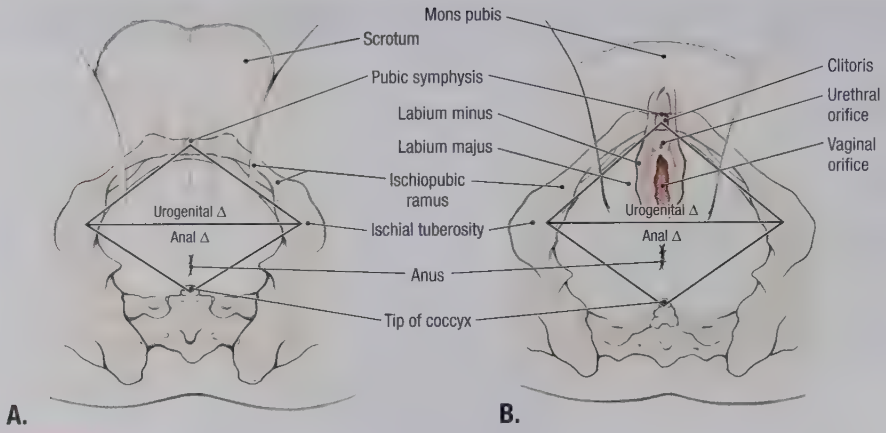

Mons pubis
Scrotum
Pubic symphysis
Labium minus
Labium majus
Ischiopubic ramus
Ischial tuberosity
Anus
Tip of coccyx
Clitoris
Urethral orifice
Vaginal orifice
Urogenital Δ
Anal Δ
Urogenital Δ
Anal Δ
A.
B.

FIGURE 5.3 ● Boundaries of the urogenital and anal triangles in the male (**A**) and female (**B**) in supine positions. Inferior views.

3. On the lateral aspects of the perineum bilaterally, palpate the **ischial tuberosities**, the lateral boundary points of both the anal and urogenital triangles.
4. Identify the **anal triangle**, the posterior part of the perineum that contains the **anal canal** and **anus**.
5. Retract the gluteal folds away from the midline and identify the **opening of anal canal**.
6. Identify the **urogenital triangle**, the anterior part of the perineum that contains the **urethra** and the **external genitalia**.
7. Observe that the urogenital triangle in the male contains the **penis** and **scrotum**.
8. Observe that the urogenital triangle in the female contains the **vulva**, the female external genitalia that includes the **labia (minora** and **majora)**, the **clitoris**, and the **vaginal** and **urethral orifices** in the space of the **vestibule**.

## Dissection Instructions

### Skin Incisions of the Gluteal Region

ATLAS 5.58; VIDEO 5.1.1

***Dissection Note:*** Prior to commencing with skin incisions, decide to either perform a full- or partial-thickness approach and to either reflect or remove the skin from the dissection field. See **Removing the Skin** in the **Introduction Chapter** for descriptions.

If the lower limb has been dissected previously, reflect the gluteus maximus muscle laterally and move ahead to the **ischioanal fossa** dissection sequence.

1. Refer to FIGURE 5.4.
2. With the cadaver in the prone position, make an incision from the tip of the coccyx (S), superiorly along the lateral border of the sacrum and the iliac crest, to the midaxillary line (T). *Note that if the back has been skinned, this incision has been made previously.*
3. Make a midline skin incision from the median sacral crest and tip of the coccyx (S) to a point near the posterior edge of the anus.
4. Make an incision that encircles the anus.

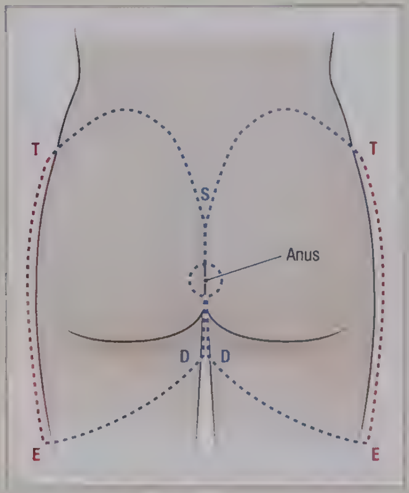

T
T
S
Anus
D
D
E
E

FIGURE 5.4 ● Skin incisions of the gluteal region. Posterior view.

5. Make an incision from the anterior edge of the anus down the medial surface of the thigh for approximately 7.5 cm (D).
6. Make a skin incision from the medial surface of the thigh (D) obliquely across the posterior surface of the thigh to the lateral surface of the thigh approximately 30 cm inferior to the iliac crest (E).
7. If reflecting the skin, use the uncut sections of skin laterally as hinge points between the iliac crest (T) and the lateral thigh (E) to leave the skin attached along the peripheral aspect of the gluteal region. Reflect the skin only as far laterally as the midaxillary line.
8. If removing the skin, make a vertical skin incision from the iliac crest (T) along the midaxillary line to the lateral aspect of the thigh (E).
9. If using a partial-thickness removal method, remove the skin but not the superficial fascia, from medial to lateral using either a pair of locking forceps or the buttonhole technique. At any point, the portions of skin may be cut into smaller segments to facilitate removal.
10. If using a full-thickness skin removal method, remove the superficial fascia from the surface of the gluteus maximus muscle along with the skin taking care to not cut too deeply. *Do not yet remove the superficial fascia inferior to the gluteus maximus muscle within the ischioanal fossa.*
11. If the skin is to be removed, detach the skin along the periphery and place it in the tissue container.

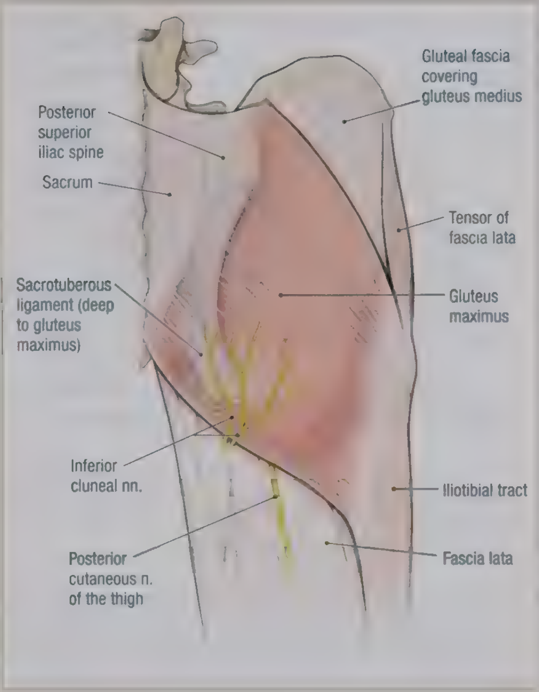

Posterior superior iliac spine
Sacrum
Sacrotuberous ligament (deep to gluteus maximus)
Inferior cluneal nn.
Posterior cutaneous n. of the thigh
Gluteal fascia covering gluteus medius
Tensor of fascia lata
Gluteus maximus
Iliotibial tract
Fascia lata

FIGURE 5.5 ■ Fascia of the gluteal region. Posterior view.

## Superficial Fascia of the Gluteal Region and the Ischioanal Fossa

ATLAS 5.50, 5.59, 5.63; VIDEO 5.1.2

***Dissection Note:*** The loose ischioanal fat is part of the superficial fascia of this region but is a different texture than the dense fat overlying the ischial tuberosities. Despite the relatively large amounts of fat, proceed slowly within the ischioanal fossa to avoid tearing the delicate neurovascular structures of the region.

1. Refer to FIGURE 5.5.
2. If you have not already done so with the skin removal, remove the superficial fascia from the surface of the **gluteus maximus** muscle superiorly and place it in the tissue container.
3. Observe that the large gluteus maximus muscles attach along its lateral aspect inferiorly to the **iliotibial tract (IT band)**, the condensation of the thick **fascia lata** of the thigh.
4. Along the inferior aspect of the gluteus maximus muscle within the superficial fascia, make an effort to identify one or two of the **inferior cluneal nerves**, the cutaneous nerve branches in the region.
5. Clean and define the inferior border of the **gluteus maximus muscle** by removing the remaining superficial fascia and separate it from the deeper fat and connective tissue. *Note that it is not necessary to save the inferior cluneal nerves but take care not to cut the **fascia lata** of the posterior thigh.*
6. Deep to the inferior border of the gluteus maximus muscle, palpate the **sacrotuberous ligament**. *Note that the gluteus maximus muscle is attached to the sacrotuberous ligament and the sacrum medially.*
7. Retract the gluteus maximus muscle superiorly to broaden the dissection field and expose the **ischioanal fat**.
8. Along the superior border of the gluteus maximus, identify the **gluteus medius** muscle but do not remove the overlying **gluteal fascia**.
9. Refer to FIGURE 5.6.
10. Lateral to the anus, use scissors to create an incision directed toward the gluteus maximus within the ischioanal fat to a depth of approximately 3 cm (**Cut 1**).
11. Using the scissor technique, or your preferred method of blunt dissection, tear and push the fat with the blunt outer edge of the scissors or a probe to enlarge the opening in the ischioanal fat.
12. Within the ischioanal fat, palpate and identify the **inferior rectal (anal) nerve** and **vessels**.

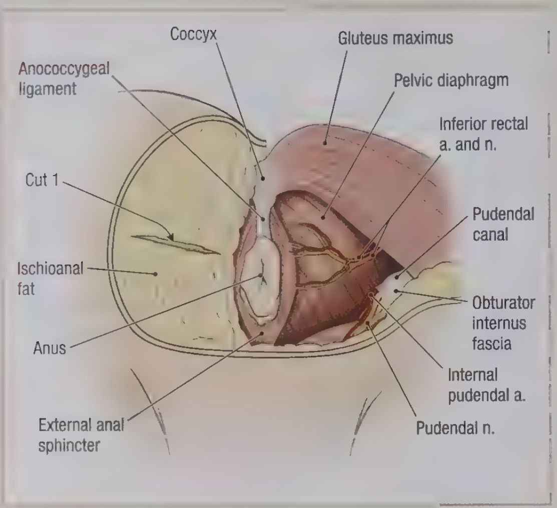


FIGURE 5.6 ● Ischioanal fossa superficial (*left*) and deep (*right*) dissections. Inferior view.

13. Preserve the branches of the inferior rectal nerve and vessels using blunt dissection to remove the surrounding fat and drying the area with paper towels if necessary. *Note that the inferior rectal nerve innervates the external anal sphincter muscle and the skin around the anus.*
14. Use blunt dissection to clean the **external anal sphincter muscle** surrounding the anus medially (part of the medial boundary of the ischioanal fossa). *Note that the external anal sphincter muscle has three parts: a subcutaneous portion encircling the anus (often destroyed in dissection), a superficial portion anchoring the anus to the perineal body and coccyx, and a deep portion forming a ring of muscle that is fused with the pelvic diaphragm.*
15. Use blunt dissection to clean the inferior surface of the **pelvic diaphragm** (the medial and superior boundaries of the ischioanal fossa). *Note that the inferior boundary of the ischioanal fossa is the skin.*
16. Use blunt dissection to expose the **fascia of the obturator internus muscle** (the lateral boundary of the ischioanal fossa).
17. Laterally, observe that the inferior rectal nerve and vessels penetrate the fascia of the obturator internus muscle through a space known as the **pudendal canal**.
18. Place gentle traction on the inferior rectal vessels and nerve and observe that a ridge is raised in the obturator internus fascia demarcating the path of the pudendal canal.
19. Gently place a probe within the pudendal canal to verify the path of the canal and carefully cut the overlying obturator fascia taking care to not cut the underlying nerves and vessels.
20. Observe that the inferior rectal vessels and nerve exit the inferior aspect of the pudendal canal to enter the ischioanal fossa. *Note that the superior aspect of the canal communicates with the* ***lesser sciatic foramen****.*
21. Use blunt dissection to elevate and clean the contents of the pudendal canal, namely the **pudendal nerve** and the **internal pudendal artery** and **vein**.

## Dissection Follow-up

1. Review the boundaries of the true pelvis and the concept that the pelvic diaphragm separates the pelvic cavity from the perineum.
2. Use the dissected specimen to review the boundaries of the ischioanal fossa.
3. Review the location of the external anal sphincter muscle, its blood supply, and its pattern of innervation as a skeletal muscle under voluntary control.
4. If a full- or partial-thickness skin reflection was performed, replace the reflected portions of skin back to anatomical position.

# MALE EXTERNAL GENITALIA AND PERINEUM

## Dissection Overview

If you are dissecting a female cadaver, go to the section entitled "**Female External Genitalia, Urogenital Triangle, and Perineum**" and use this section for review with a male cadaver.

In the embryo, the scrotum forms as an outpouching of the anterior abdominal wall during the descent of the testis; therefore, most layers of the abdominal wall are represented in the scrotum. The superficial fascia of the scrotum is represented by dartos fascia, which contains smooth muscle fibers (dartos muscle) and no fat.

The spermatic cord contains the ductus deferens, testicular vessels, lymphatics, and nerves, the structures connecting between the testis and the abdominopelvic cavity. The contents of the spermatic cord are surrounded by three fascial layers, the coverings of the spermatic cord, derived from layers of the anterior abdominal wall. Each layer was added to the spermatic cord as the testis and associated structures passed through the inguinal canal during development.

The order of dissection will be as follows: The scrotum will be opened by a vertical cut along its anterior surface. The spermatic cord will be followed from the superficial inguinal ring into the scrotum. The testis will be removed from the scrotum. The spermatic cord will be dissected. The testis will be studied.

## Skeletal Anatomy

Refer to an articulated bony pelvis and identify the following skeletal features.

### *Skeleton of the Male Pelvis*

ATLAS 5.3A, 5.5A, 5.8A

1. Refer to FIGURE 5.7.
2. Identify the three bones comprising the hip bone: **pubis**, **ischium**, and **ilium**.
3. In the **erect posture** (anatomical position), the **anterior superior iliac spines** and the anterior aspect of the pubis at the **pubic tubercles** are in the same coronal plane. In this position, the plane of the pelvic inlet forms an angle of approximately 55° to the horizontal.
4. On the anterior surface of the hip bone, identify the **iliac fossa**. Observe that the iliac fossae are directed toward one another and form the lateral boundaries of the **false (greater) pelvis**, the portion of the bony pelvis superior to the **pelvic (inlet) brim**.
5. Observe that the pelvic inlet is formed by the **sacral promontory** and **anterior border of the ala (wing) of the sacrum** posteriorly, the arcuate line of the ilium laterally, and the pecten pubis and pubic crest of the pubic bones anteriorly, which meet at the **pubic symphysis**.
6. Observe that the lesser pelvis is located inferior to the pelvic brim and surrounded by bone. *Note that the inferior boundary of the lesser pelvis is the pelvic diaphragm.*
7. Identify the **obturator foramen**, the large opening on the anterior aspect of the pelvis.
8. Observe that in anatomical position, the obturator foramen faces inferiorly and is bound anteriorly by the **superior pubic ramus**, medially by the **ischiopubic ramus**, and laterally by the body of the **ischium**.
9. Observe that the ischiopubic ramus is formed by the **ischial ramus** and the **inferior pubic ramus**, often not easily delineated.
10. Compare a male and female bony pelvis and observe that the **subpubic angle** (angle of the pubic arch) is wider in females than in males.

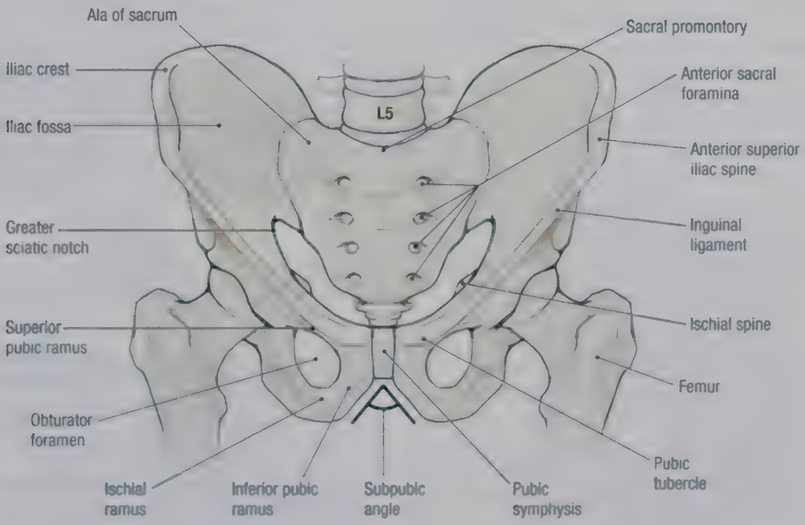

Ala of sacrum
Sacral promontory
Iliac crest
Anterior sacral foramina
Iliac fossa
L5
Anterior superior iliac spine
Greater sciatic notch
Inguinal ligament
Superior pubic ramus
Ischial spine
Femur
Obturator foramen
Pubic tubercle
Ischial ramus
Inferior pubic ramus
Subpubic angle
Pubic symphysis

FIGURE 5.7 ● The male bony pelvis. Anterior view.

## Surface Anatomy

The surface anatomy of the abdomen may be studied on a living subject or on a cadaver. On the cadaver, note that fixation of tissue during embalming may make it difficult to distinguish bone from well-preserved soft tissues in some specimens.

## Male Urogenital Triangle

ATLAS 5.1, 5.45

1. Refer to FIGURE 5.8.
2. Place the body in a supine position. Stretch the thighs widely apart and brace them.
3. Identify the **shaft of the penis**, the pendant male reproductive organ located in the midline.
4. Observe that the shaft of the penis connects to the body in the pubic region at the **root of the penis**.
5. Deep to the skin, identify the **suspensory ligament of the penis** coursing through the subcutaneous tissue providing additional fibrous support to the penis.
6. At the distal end of the shaft of the penis, identify the **glans of the penis**, demarcated from the shaft by the ridge of tissue forming the **corona**. *Note that in an uncircumcised penis, the glans is either partially or fully covered by the prepuce, or foreskin.*
7. Identify the **external urethral orifice**, the terminal distal end of the male penile urethra.
8. Posterior to the penis, identify the **scrotum**, the extension of skin surrounding the bilaterally located testes.

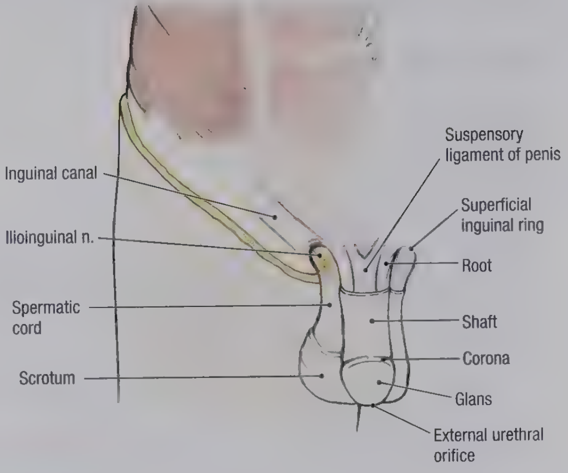

Suspensory ligament of penis
Inguinal canal
Superficial inguinal ring
Ilioinguinal n.
Root
Spermatic cord
Shaft
Corona
Scrotum
Glans
External urethral orifice

FIGURE 5.8 ● Surface anatomy of the male external genitalia. Anterior view.

## Dissection Instructions

### Scrotum

ATLAS 4.16, 5.45, 5.48D; VIDEO 5.2.1

***Dissection Note:*** The dissection of the scrotum corresponds to the dissection of the labium majus in female cadavers. Partner with a dissection team that has a female cadaver for the dissection of the external genitalia because you are expected to observe and learn the anatomy for both sexes.

1. Refer to FIGURE 5.8.
2. Identify the **spermatic cord** emerging from the **superficial inguinal ring**.
3. Beginning inferior to the superficial inguinal ring, push your finger or a blunt instrument deep to the subcutaneous tissue of the lower anterior abdominal wall, down into the scrotum creating a space around the spermatic cord along its path of descent.
4. Refer to FIGURE 5.9.
5. Make a vertical incision down the anterior surface of the scrotum along the path of the enlarged space cutting through the skin, dartos, and superficial fascia, ensuring you do not cut the spermatic cord (**Cut 1**).
6. Free the testis and spermatic cord from the scrotum.
7. Identify the **scrotal ligament** (the remnant of the **gubernaculum testis**), a band of tissue anchoring the inferior pole of the testis to the scrotum.
8. Use scissors to cut the scrotal ligament.
9. Remove the testis from the scrotum but leave the testis attached to the spermatic cord.
10. Observe that the **scrotal septum** divides the scrotum into two compartments.

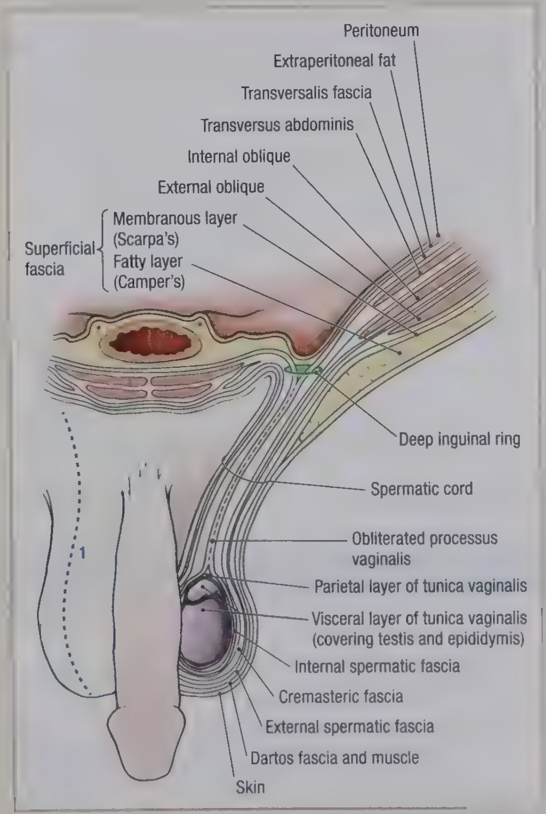

Peritoneum
Extraperitoneal fat
Transversalis fascia
Transversus abdominis
Internal oblique
External oblique
Superficial fascia
Membranous layer (Scarpa's)
Fatty layer (Camper's)
Deep inguinal ring
Spermatic cord
1
Obliterated processus vaginalis
Parietal layer of tunica vaginalis
Visceral layer of tunica vaginalis (covering testis and epididymis)
Internal spermatic fascia
Cremasteric fascia
External spermatic fascia
Dartos fascia and muscle
Skin

FIGURE 5.9 ● Contributions of the anterior abdominal wall to the spermatic fascia. Anterior view.

### Spermatic Cord

ATLAS 4.16, 4.19, 5.53; VIDEO 5.2.2

***Dissection Note:*** Perform the following dissection sequence on only one side.

1. Refer to FIGURE 5.9 and FIGURE 5.10.
2. Palpate the spermatic cord and identify the location of the **ductus deferens (vas deferens)** within the surrounding fascia. Observe that the vas deferens is the hardest and most "cord-like" structure in the spermatic cord.
3. Carefully make a vertical incision through the outermost coverings of the spermatic cord derived from the external oblique aponeurosis, the **external spermatic fascia (Cut 1)**.
4. Gently spread apart the external spermatic fascia and make attempts to identify the **cremasteric muscle and fascia** derived from the internal oblique muscle and aponeurosis.
5. Make a vertical incision through the cremasteric muscle and fascia and the deepest of the three spermatic cord coverings, the **internal spermatic fascia**, derived from the transversalis fascia **(Cut 2)**.
6. Identify the now exposed **ductus (vas) deferens** and use blunt dissection to separate it from the surrounding **pampiniform plexus of veins**.
7. Within the plexus of vein, identify the **artery of the ductus deferens,** a small vessel located on the surface of the ductus deferens.
8. Follow the ductus deferens superiorly through the inguinal canal toward the deep inguinal ring and observe that the ductus deferens passes through the deep inguinal ring lateral to the inferior epigastric vessels.
9. Identify the **testicular artery** and use blunt dissection to separate it from the pampiniform plexus of veins. Observe that the testicular artery can be distinguished from the veins by its slightly thicker wall and its tortuous course. *Note that sensory nerve fibers, autonomic nerve fibers, and lymphatic vessels accompany the blood vessels in the spermatic cord but that they are too small to dissect.*

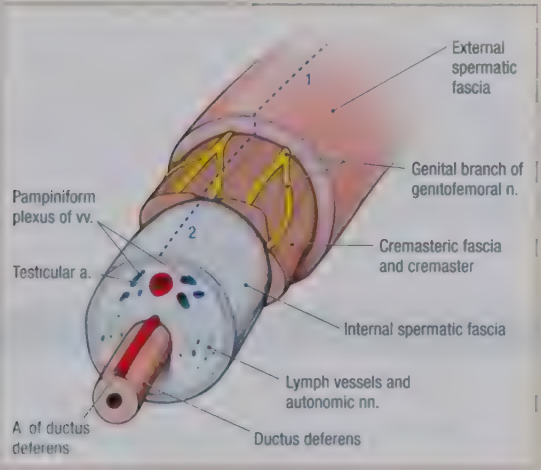

External spermatic fascia
1
Genital branch of genitofemoral n.
Pampiniform plexus of vv.
2
Cremasteric fascia and cremaster
Testicular a.
Internal spermatic fascia
Lymph vessels and autonomic nn.
A. of ductus deferens
Ductus deferens

FIGURE 5.10 ● Transverse sections through the spermatic cord. Oblique view.

**CLINICAL CORRELATION**

#### Vasectomy

ATLAS 5.22B

The ductus deferens can be surgically interrupted through ligation or excision in the superior part of the scrotum, a procedure known as a vasectomy or deferentectomy. Sperm production in the testis continues, but the spermatozoa cannot reach the urethra; thus, following a vasectomy, ejaculated fluid will no longer contain sperm, rendering the male sterile.

### Testis

ATLAS 4.16B, 4.20B, 5.53C; VIDEO 5.2.3

1. Refer to FIGURE 5.11.
2. Within the scrotum, observe that the testis is covered by the **tunica vaginalis,** a serous sac derived from the parietal peritoneum with both parietal and visceral layers.
3. Use scissors to cut the outer **parietal layer of the tunica vaginalis** along its anterior surface and open it widely.

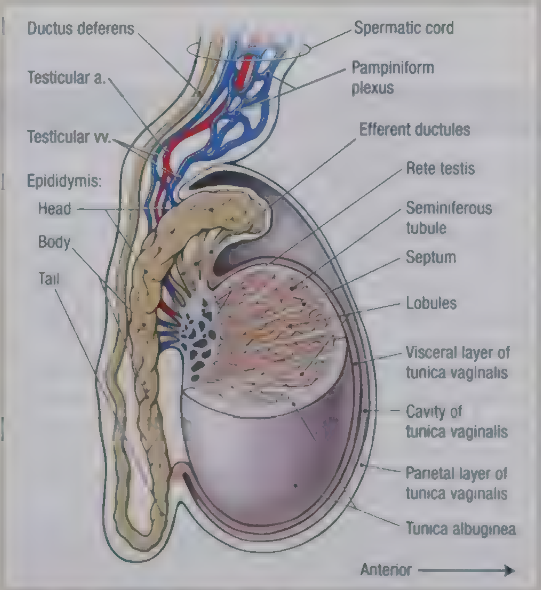

Ductus deferens
Spermatic cord
Testicular a.
Pampiniform plexus
Efferent ductules
Testicular vv.
Rete testis
Epididymis:
Head
Body
Tail
Seminiferous tubule
Septum
Lobules
Visceral layer of tunica vaginalis
Cavity of tunica vaginalis
Parietal layer of tunica vaginalis
Tunica albuginea
Anterior

FIGURE 5.11 ● Parts of the right testis and epididymis. Lateral view.

4. Observe that the **visceral layer of the tunica vaginalis** covers the anterior, medial, and lateral surfaces of the **testis** but not its posterior surface. *Note that the cavity of the tunica vaginalis is a potential space containing a very small amount of serous fluid.*
5. Use blunt dissection to follow the ductus deferens inferiorly until it joins the **epididymis**.
6. Identify the **head of the epididymis**, the superior expanded part that receives the efferent ductules.
7. Identify the **body of the epididymis**, the middle part that is narrower in diameter than the head, and the **tail of the epididymis**, the inferior part that turns superiorly to join the ductus deferens.
8. Use a scalpel to carefully section the testis along its anterior surface longitudinally from its superior pole to its inferior pole but do not cut completely through the testis.
9. Use the epididymis as a hinge and open the halves of the testis as you would open a book.
10. Observe the thickness of the **tunica albuginea**, the fibrous capsule of the testis, from the cross-sectional view.
11. Identify the **septa** that divide the interior of the testis into **lobules**.
12. Use a needle or fine-tipped forceps to tease some of the **seminiferous tubules** out of one lobule and observe their convoluted appearance and tight organization.

**CLINICAL CORRELATION**

### Lymphatic Drainage of the Testis

ATLAS 4.20C

Lymphatics from the scrotum drain to the superficial inguinal lymph nodes. Inflammation of the scrotum may cause tender, enlarged superficial inguinal lymph nodes.

In contrast, lymphatics from the testis follow the testicular vessels through the inguinal canal and into the abdominal cavity, where they drain into lumbar (lateral aortic) and preaortic lymph nodes. Testicular tumors may metastasize to lumbar and preaortic lymph nodes, not to superficial inguinal lymph nodes.

## Dissection Follow-up

1. Review the course of the ductus deferens from the abdominal wall to the testis.
2. Review the coverings of the spermatic cord and review the layers of the abdominal wall from which they are derived.
3. Trace the route of spermatozoa from their origin in the seminiferous tubule to the ejaculatory duct.
4. Replace the reflected portions of tissue back to anatomical position.
5. Visit a dissection table with a female cadaver and complete the **Dissection Follow-up** that follows the dissection of the labium majus.

# MALE UROGENITAL TRIANGLE

## Dissection Overview

Like the lower anterior abdomen, the superficial perineal fascia has a superficial fatty layer and a deep membranous layer. The superficial fatty layer is continuous with Camper's fascia (the superficial fatty layer of the anterior abdominal wall) and the fatty fasciae in the ischioanal fossa and thigh. The membranous layer of the superficial perineal fascia (Colles' fascia) is continuous with the membranous layer of the superficial fascia of the anterior abdominal wall (Scarpa's fascia) and the dartos fascia of the penis and scrotum as shown in FIGURE 5.12.

The order of dissection of the male urogenital triangle will be as follows: The skin will be removed from the urogenital triangle. The superficial perineal fascia will be removed, and the contents of the superficial perineal pouch will be identified. The skin will be removed from the penis, and its parts will be studied. The contents of the deep perineal pouch will be described but not dissected.

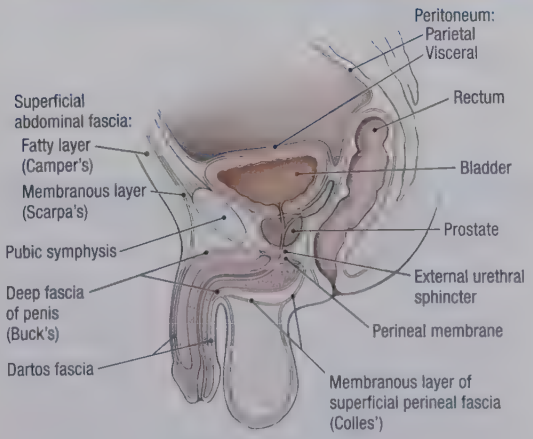

Peritoneum:
Parietal
Visceral
Rectum
Superficial abdominal fascia:
Fatty layer (Camper's)
Membranous layer (Scarpa's)
Bladder
Prostate
Pubic symphysis
External urethral sphincter
Deep fascia of penis (Buck's)
Perineal membrane
Dartos fascia
Membranous layer of superficial perineal fascia (Colles')

FIGURE 5.12 ● Fasciae of the male perineum. Midsagittal view.

## Dissection Instructions

### Skin Incisions of the Male Urogenital Triangle

ATLAS 5.45, 5.53A; VIDEO 5.3.1

***Dissection Note:*** Partner with a dissection team that has a female cadaver for the dissection of the urogenital triangle to compare the two sexes. It is recommended to perform a partial-thickness skin removal technique leaving the subcutaneous tissue intact because cutting too deeply may easily damage many of the structures in the region. To facilitate dissection, position yourself between the thighs with the trunk of the cadaver pulled toward the end of the dissection table.

1. Refer to FIGURE 5.13.
2. With the cadaver in the supine position, stretch the thighs widely apart and brace them.
3. Make a skin incision that encircles the proximal end of the penis (R), making sure to not cut too deeply because the skin is very thin in this region.
4. Make a midline skin incision posterior to the proximal end of the penis (R) that splits the scrotum along the scrotal septum to the anterior margin of the anus (J).
5. Make an incision in the midline superior to the penis to the point where the skin of the abdomen was removed previously.
6. Make a transverse incision across the midline superior to the penis to the anterior aspect of the right thigh (N) and to the anterior aspect of the left thigh (N). *Note that if the abdomen was previously dissected, a portion of this incision was already made.*
7. Make a skin incision connecting from the anterior aspect of each thigh (N) posteriorly to a point in the posterior thigh (M) in line with the horizontal incision bifurcating the anterior margin of the anus (J).
8. Reflect the skin flaps from medial to lateral.
9. Detach the scrotum and skin flaps along the medial thigh and place them in the tissue container.
10. If the cadaver has a large amount of fat in the superficial fascia of the medial thighs, remove a portion of the superficial fascia from the region of removed skin.

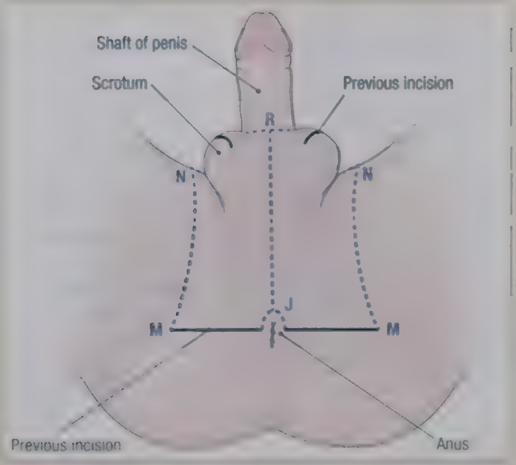


FIGURE 5.13 ■ Skin incisions for the male perineum. Inferior view.

**CLINICAL CORRELATION**

### Rupture of the Male Urethra

ATLAS 5.51B, 5.52B

If the urethra is injured in the perineum along the path of the penile or spongy urethra, urine may escape into the superficial perineal pouch as illustrated in FIGURE B5.1. The urine may spread into the shaft of the penis if the deep fascia (Buck's) is not compromised or into the scrotum, penis, and upward into the lower abdominal wall if the deep fascia is also ruptured. The fluid would extend into the space between the membranous layer of the abdominal superficial fascia (Scarpa's fascia) and the investing (deep) fascia covering the aponeurosis of the external oblique muscle.

If the urethra is ruptured at the level of the membranous or intermediate urethra by comparison, extravasation of urine and blood occurs into the deep perineal pouch or compartment. Fluid in the deep perineal pouch may pass through the urogenital hiatus to enter the pelvic cavity and spread around the prostate or bladder internally.

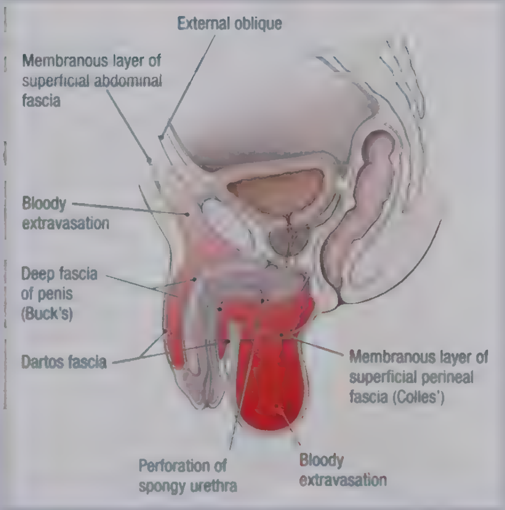

External oblique
Membranous layer of superficial abdominal fascia
Bloody extravasation
Deep fascia of penis (Buck's)
Dartos fascia
Membranous layer of superficial perineal fascia (Colles')
Perforation of spongy urethra
Bloody extravasation

FIGURE B5.1 ■ Rupture of the penile urethra in the perineum with extravasated urine and blood in the superficial perineal pouch and lower abdomen wall. Midsagittal view.

## Male Superficial Perineal Pouch

ATLAS 5.47A, 5.50; VIDEO 5.3.2

1. Refer to FIGURE 5.14A.
2. In the male, three pairs of muscles (left and right) overlie the erectile tissue of the root of the penis and contribute to the **contents of the superficial perineal pouch** along with the erectile tissues and the accompanying **arteries, veins, and nerves** that supply the structures. The three muscles are the **ischiocavernosus muscle, bulbospongiosus muscle,** and the **superficial transverse perineal muscle**.
3. Identify the **posterior scrotal nerve and vessels** and observe that they are terminal branches of the **superficial branch of the perineal artery and nerve** and supply the posterior part of the scrotum. *Note that the superficial branch of the perineal artery and nerve enter the urogenital triangle by passing lateral to the external anal sphincter muscle.*
4. It is not necessary to identify the **membranous layer of the superficial perineal fascia (Colles' fascia)** to complete the dissection. Rather, review the attachments of Colles' fascia by palpating the **ischiopubic ramus** and **ischial tuberosity** as well as the posterior edge of the **perineal membrane**. *Note that Colles' fascia forms the superficial boundary of the* ***superficial perineal pouch*** *(space).*
5. Use blunt dissection to find the **bulbospongiosus muscle** in the midline of the urogenital triangle.
6. Observe that the bulbospongiosus muscle covers the surface of the **bulb of the penis**, the central tube of erectile tissue containing the urethra, and lies anterior to the thick fascia of the **perineal body**.
7. Review the attachments and actions of the **bulbospongiosus muscle** (see **TABLE 5.1**).
8. Lateral to the bulbospongiosus muscle, clean the surface of the **ischiocavernosus muscle** overlying the surface of the **crus of the penis**.
9. Using blunt dissection, attempt to find the **superficial transverse perineal muscle** at the posterior border of the urogenital triangle.
10. Observe that the superficial transverse perineal muscle helps to support the **perineal body**,

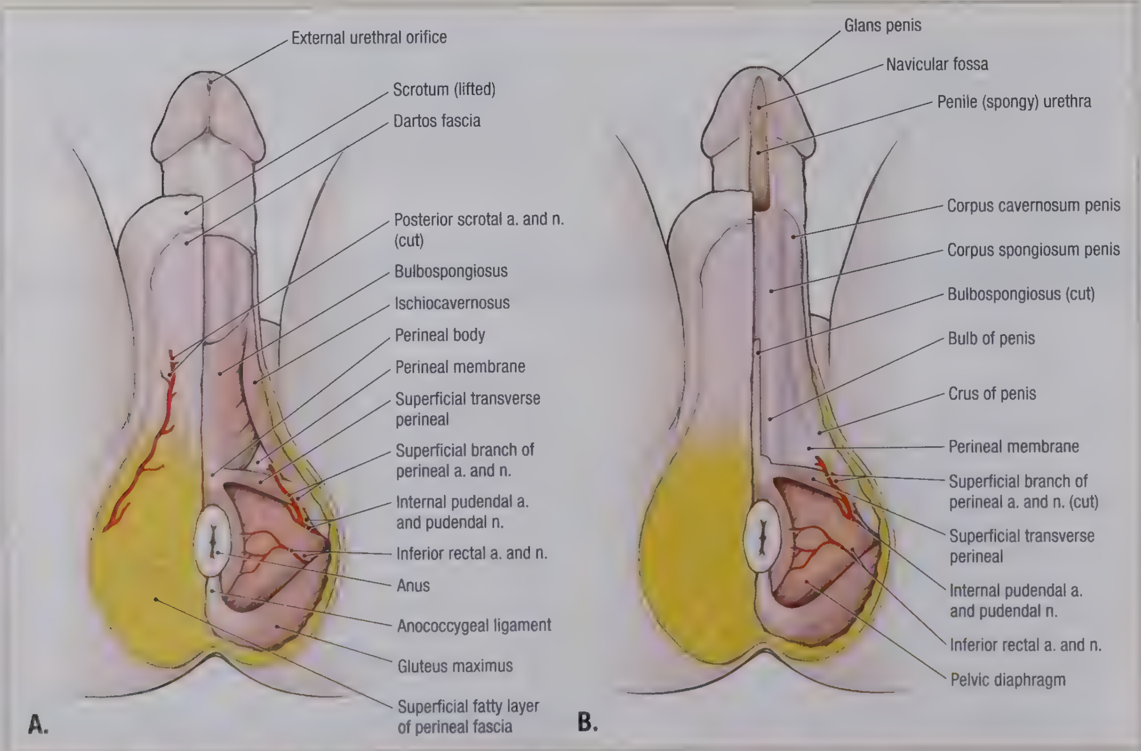

External urethral orifice
Scrotum (lifted)
Dartos fascia
Posterior scrotal a. and n. (cut)
Bulbospongiosus
Ischiocavernosus
Perineal body
Perineal membrane
Superficial transverse perineal
Superficial branch of perineal a. and n.
Internal pudendal a. and pudendal n.
Inferior rectal a. and n.
Anus
Anococcygeal ligament
Gluteus maximus
Superficial fatty layer of perineal fascia
A.
Glans penis
Navicular fossa
Penile (spongy) urethra
Corpus cavernosum penis
Corpus spongiosum penis
Bulbospongiosus (cut)
Bulb of penis
Crus of penis
Perineal membrane
Superficial branch of perineal a. and n. (cut)
Superficial transverse perineal
Internal pudendal a. and pudendal n.
Inferior rectal a. and n.
Pelvic diaphragm
B.

FIGURE 5.14 • Contents of the male superficial perineal pouch in superficial (A) and deep (B) dissections. Inferior views.

a fibromuscular mass located anterior to the anal canal and posterior to the perineal membrane. *Note that the superficial transverse perineal muscle may be delicate and difficult to find. Limit the time you spend looking for it.*

11. Use blunt dissection to clean between the muscles of the superficial perineal pouch until a small triangular opening is created.
12. Within the triangular opening, identify the **perineal membrane**. The perineal membrane is the deep boundary of the superficial perineal pouch.
13. Use a scalpel to make a shallow incision along the midline raphe of the bulbospongiosus muscles. Take care because this is a thin muscle and effort must be taken to not cut too deeply.
14. Remove the bulbospongiosus muscle on the left side of the cadaver.
15. Refer to FIGURE 5.14B.
16. Identify the **bulb of the penis** and use an illustration to observe that it is continuous with the corpus spongiosum penis and contains a portion of the spongy urethra.
17. On the left side of the cadaver, use blunt dissection to remove the ischiocavernosus muscle from the **crus of the penis**.
18. Verify that the crus of the penis attaches to the ischiopubic ramus and is continuous with the corpus cavernosum penis.

## Penis

ATLAS 5.54, 5.55; VIDEO 5.3.3

***Dissection Note:*** In anatomical position, the penis is erect, thus making the surface of the penis closest to the anterior abdominal wall the dorsal surface of the penis. The superficial fascia of the penis (dartos fascia) has no fat and contains the superficial dorsal vein of the penis, which may be easily cut if the skin incisions are made too deep.

1. Refer to FIGURE 5.14.
2. Identify the **root of the penis**, the part of the penis attached to the ischiopubic rami (bulb and crura).
3. Identify the **body (shaft) of the penis**, the part of the penis that is pendant (corpora cavernosa and corpus spongiosum penis).
4. Identify the **glans penis** at the distal end of the penis. Use an illustration to observe that it is continuous with the corpus spongiosum penis and thus contains the urethra, which terminates at the **external urethral orifice**, and erectile tissue.
5. Around the circumference of the glans, identify the **corona of the glans**. In an uncircumcised specimen, identify the **prepuce** (foreskin).

**CLINICAL CORRELATION**

### Circumcision

ATLAS 5.54

Circumcision is the removal of the foreskin or prepuce of the penis. An uncircumcised prepuce covers all or part of the glans, whereas a circumcised prepuce would leave the glans either fully or partially exposed. Smegma, or accumulations of secretions, may accumulate within the preputial sac, the space between the glans and the prepuce in an uncircumcised penis, leading to irritation and sensitivity. Occasionally, the prepuce is not elastic enough to fully retract over the glans during an erection or intercourse, a condition known as phimosis, which may need surgical correction.

6. Observe the midline location of the **frenulum** on the ventral surface of the glans connecting along the distal shaft of the penis.
7. Use a scalpel to make a shallow midline skin incision through the skin down the ventral surface of the penis. Using a probe, gently elevate the skin from around the body of the penis and detach it by cutting it just proximal to the corona of the glans. Do not skin the glans.
8. Refer to FIGURE 5.15.

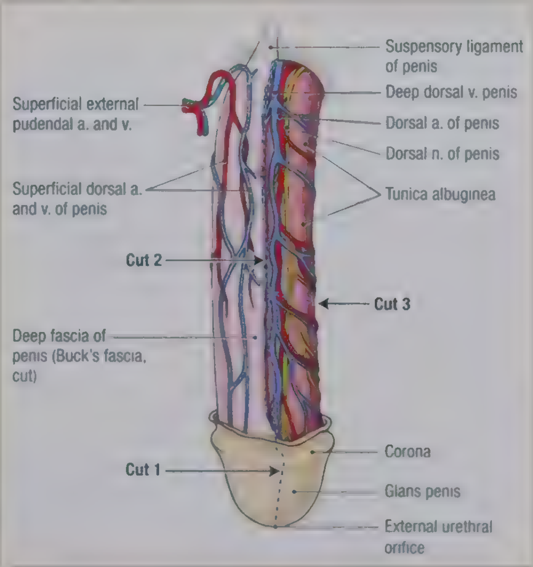

Superficial external pudendal a. and v.
Suspensory ligament of penis
Deep dorsal v. penis
Dorsal a. of penis
Dorsal n. of penis
Superficial dorsal a. and v. of penis
Tunica albuginea
Cut 2
Cut 3
Deep fascia of penis (Buck's fascia, cut)
Corona
Cut 1
Glans penis
External urethral orifice

FIGURE 5.15 ■ Exposed arteries and nerves of the penis with skin (*left*) and superficial fascia (*right*) removed. Dorsal view.

9. On the dorsal surface of the penis, identify and clean the **superficial dorsal vein**. The superficial dorsal vein of the penis drains into the **superficial external pudendal vein**, which drains into the great saphenous vein.
10. On the dorsum of the penis, use a probe to dissect through the **deep fascia of the penis** and identify the **deep dorsal vein of the penis** (unpaired) in the midline. *Note that most of the blood from the penis drains through the deep dorsal vein into the **prostatic venous plexus**.*
11. Identify and clean the **dorsal artery of the penis** (paired) on each side of the deep dorsal vein. The dorsal artery of the penis is a terminal branch of the internal pudendal artery.
12. Identify and clean the **dorsal nerve of the penis** (paired) on each side of the midline lateral to the deep dorsal artery. *Note that the dorsal nerve of the penis is a branch of the pudendal nerve.*
13. Use blunt dissection to trace the dorsal artery and nerve of the penis proximally.
14. Observe that the dorsal artery and nerve of the penis course deep to the perineal membrane before they emerge onto the dorsum of the penis. The deep dorsal vein passes between the pubic arch and the anterior edge of the perineal membrane to enter the pelvis. *Note that the deep dorsal vein does not accompany the deep dorsal artery and dorsal nerve proximal to the body of the penis.*

## Spongy (Penile) Urethra

ATLAS 5.54B, 5.56; VIDEO 5.3.4

***Dissection Note:*** The male urethra is described as having four regions: the preprostatic urethra, the prostatic urethra, the membranous urethra, and the spongy (penile) urethra. The spongy urethra is the portion located within the corpus spongiosum penis. To examine the internal features of the spongy urethra, the glans and shaft of the penis will be cut longitudinally along the midline and one haft transected axially.

1. Refer to FIGURE 5.15.
2. Identify the **external urethral orifice** at the tip of the glans penis.
3. Gently insert a probe into the external urethral orifice and use a scalpel to cut down to the probe from both the dorsal and ventral surfaces of the penis in the median plane of the penis (**Cut 1**). *Note that the pathway of the spongy urethra may not be a straight line or may be slightly off center.*
4. Advance the probe proximally and continue to divide the penis until you reach a point inferior to the pubic symphysis where the two corpora cavernosa separate from the bulb of the penis (**Cut 2**). Dorsal to the probe, the cut should pass between the corpora cavernosa and possibly split the deep dorsal vein longitudinally. Ventral to the probe, the cut should divide the corpus spongiosum into equal halves.
5. Carefully continue the cut through the bulb of the penis posterior to the urethra but do not cut through the perineal membrane. *Note that the urethra bends at a sharp angle and passes through the perineal membrane.*
6. Observe the sagittal section of the penis and identify the **glans penis**, the distal expansion of the corpus spongiosum. *Note that the glans penis caps the two corpora cavernosa penis at the distal extent of the penis.*
7. Identify the spongy urethra and observe that it terminates by passing through the glans to the external urethral orifice.
8. Examine the interior of the spongy urethra at the glans penis and identify the **navicular fossa**, a widening of the urethra.
9. In the proximal part of the spongy urethra (in the bulb), look for the openings of the ducts of the bulbourethral glands. *Note that the opening of the ducts may be too small to see.*
10. On the left side of the penis, make a transverse cut through the body of the penis about midway down its length (**Cut 3**).
11. Refer to FIGURE 5.16.
12. Observe that the deep fascia of the penis (Buck's fascia) is an investing fascia and surrounds the corpus spongiosum penis (unpaired), the corpus cavernosum penis (paired), the deep dorsal vein of the penis (unpaired), the dorsal artery of the penis (paired), and the dorsal nerve of the penis (paired).

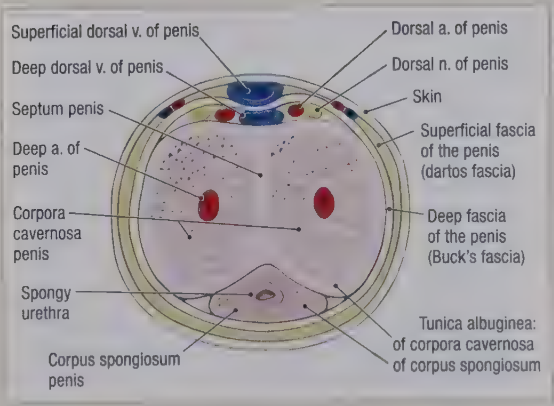


FIGURE 5.16 ■ Transverse section through midshaft of the penis. Inferior view.

13. On the dorsal aspect of the transversely cut surface, identify the **corpus cavernosum penis** and observe that it is surrounded by the thick fascia of the **tunica albuginea of the corpus cavernosum penis.** *Note that the bisection of the penis likely cut through the **septum penis**, which separates the corpora cavernosa of the penis.*
14. On the ventral aspect of the transversely cut surface, identify the **corpus spongiosum penis** and observe that it is surrounded by the **tunica albuginea of the corpus spongiosum penis.**
15. Study the erectile tissue within the corpus spongiosum penis and confirm that the corpus spongiosum penis surrounds the spongy urethra.
16. Study the erectile tissue within the corpus cavernosum penis and identify the **deep artery of the penis** near the center of the erectile tissue. *Note that the origin of the deep artery of the penis is the internal pudendal artery.*

## Male Deep Perineal Pouch

ATLAS 5.47C, 5.47D; VIDEO 5.3.5

***Dissection Note:*** The deep perineal pouch lies superior (deep) to the perineal membrane and will be minimally dissected, as few of the structures are easily identifiable.

1. Refer to FIGURE 5.17.
2. Identify the **membranous urethra** in the midsagittal plane and observe that it pierces the **perineal membrane**. The membranous urethra extends from the perineal membrane to the prostate gland and is the shortest (about 1 cm), thinnest, narrowest, and least distensible part of the urethra.
3. Surrounding the membranous urethra, identify the **external urethral sphincter muscle (sphincter urethrae)**. *Note that the external urethral sphincter muscle is a voluntary muscle that when contracted acts to compress the membranous urethra and stop the flow of urine.*
4. Posterolateral to the urethra, identify the **bulbourethral glands**. The **bulbourethral gland** (paired) is located in the deep perineal pouch but its duct passes through the perineal membrane and drains into the proximal portion of the spongy urethra in the superficial perineal pouch.
5. Identify the **deep transverse perineal muscle** (paired) along the posterior margin of the deep perineal pouch. Collectively, the muscles within the deep perineal pouch plus the perineal membrane are known as the **urogenital diaphragm**. *Note that the deep transverse perineal fiber direction and function are identical to those of the superficial transverse perineal muscle, which is in the superficial perineal pouch.*
6. Review the attachments and actions of the **external urethral sphincter** and the **deep transverse perineal muscle** (see TABLE 5.1).
7. Coursing anteriorly along the lateral margin of the deep perineal pouch, identify the **branches of the internal pudendal artery and vein** (most notably, the dorsal artery of the penis) and the **branches of the pudendal nerve** (most notably, the dorsal nerve of the penis). *Note that the pudendal neurovascular structures supply the external urethral sphincter muscle, the deep transverse perineal muscle, and the penis.*

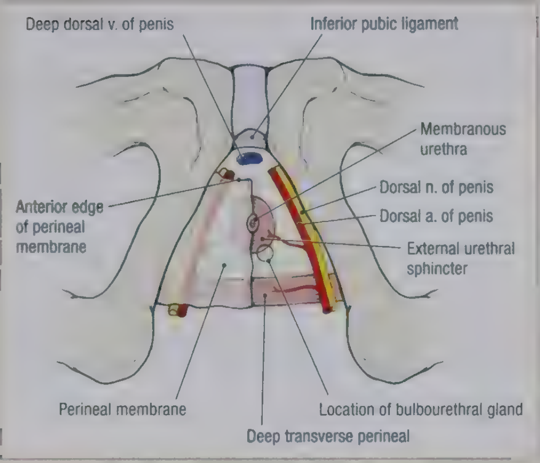


FIGURE 5.17 ● Contents of the male deep perineal pouch. Inferior view.

## Dissection Follow-up

1. Review the muscles of the male superficial perineal pouch in **TABLE 5.1**.
2. Visit a dissection table with a female cadaver and view the contents of the superficial perineal pouch.
3. Review the course of the internal pudendal artery from its origin in the pelvis to the dorsum of the penis.
4. Review the course and branches of the pudendal nerve.
5. Review the course of the deep dorsal vein of the penis into the pelvis to join the prostatic venous plexus.
6. Review the parts of the male urethra.
7. Return the muscles of the urogenital triangle and reflected portions of tissue to their correct anatomical positions.

**TABLE 5.1** **Male Superficial and Deep Perineal Pouches**

SUPERFICIAL GROUP OF MUSCLES

| *Muscle* | *Anterior Attachments* | *Posterior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Bulbospongiosus | Contralateral bulbospongiosus muscle at the midline raphe | Perineal body | Compress the bulb of the penis to expel urine or semen | Deep branch of the perineal n. (branch of pudendal n.) |
| Ischiocavernosus | Crus of the penis | Ischial tuberosity and ischiopubic ramus | Forces blood from the crus of the penis into the distal part of the corpus cavernosum penis | |
| Superficial transverse perineal | Perineal body (medial attachment) | Ischial tuberosity (lateral attachment) | Provides support to the perineal body | Perineal n. (branch of pudendal n.) |

DEEP GROUP OF MUSCLES

| *Muscle* | *Anterior Attachments* | *Posterior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Deep transverse perineal | Perineal body (medial attachment) | Ischial tuberosity (lateral attachment) | Provides support to the perineal body | Perineal n. (branch of pudendal n.) |
| External urethral sphincter | Attaches to itself around the urethra | | Compresses the membranous urethra and stops the flow of urine | Deep branch of the perineal n. (branch of pudendal n.) |

Abbreviation: n., nerve.

# MALE PELVIC CAVITY

## Dissection Overview

The male pelvic cavity contains the urinary bladder, male internal genitalia, and the rectum as shown in FIGURE 5.18. The organs within the true pelvis are often classified as infraperitoneal because they are located inferior to the peritoneum. Recall that the pelvic structures are located superior to the pelvic diaphragm and the perineal membrane.

The order of dissection will be as follows: The peritoneum will be studied in the male pelvic cavity. The pelvis will be sectioned in the midline, and the cut surface of the sectioned pelvis will be studied. The ductus deferens will be traced from the anterior abdominal wall to the region between the urinary bladder and rectum. The seminal vesicles and prostate gland will be studied.

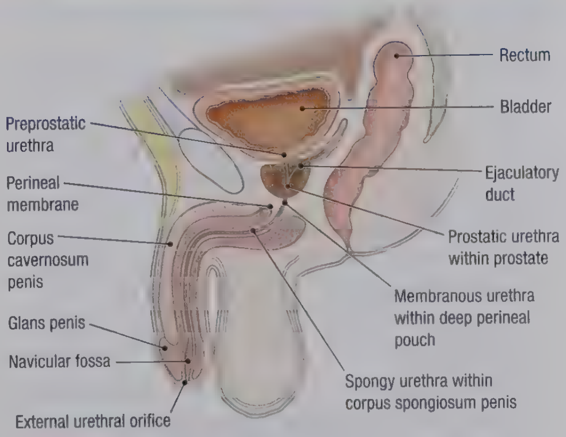

Rectum
Bladder
Preprostatic urethra
Ejaculatory duct
Perineal membrane
Prostatic urethra within prostate
Corpus cavernosum penis
Membranous urethra within deep perineal pouch
Glans penis
Navicular fossa
Spongy urethra within corpus spongiosum penis
External urethral orifice

FIGURE 5.18 ● Parts of the male urethra. Midsagittal view.

## Dissection Instructions

### Male Pelvic Peritoneum

ATLAS 5.15, 5.20; VIDEO 5.4.1

1. Refer to FIGURE 5.19.
2. Identify the peritoneum on the posterior aspect of the anterior abdominal wall superior to the pubis (**1**).
3. Observe that the peritoneum reflects from the anterior abdominal wall inferiorly across the apex of the urinary bladder (**2**).
4. Observe that in the male the peritoneum courses along the superior surface of the urinary bladder (**3**) and its posterior surface superiorly (**4**).
5. Identify the **paravesical fossa** (paired), the shallow depressions in the peritoneal cavity on the lateral sides of the urinary bladder.
6. Observe that the peritoneum descends posterior to the bladder in close proximity to the superior ends of the seminal vesicles (**5**).
7. Use a probe to follow the peritoneum posterior to the bladder and identify the **rectovesical pouch** (**6**),

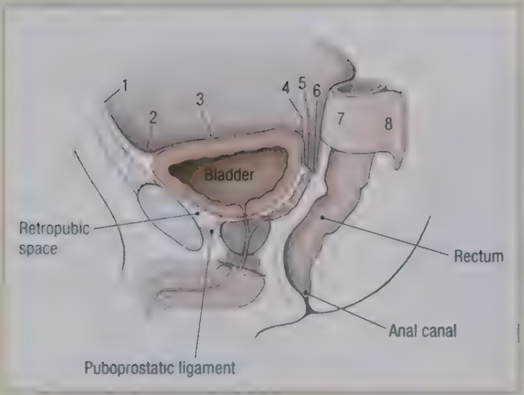


FIGURE 5.19 ■ Male pelvic peritoneum. Midsagittal view.

the reflection point between the urinary bladder and the rectum. *Note that the rectovesical pouch is the lowest point in the male abdominopelvic cavity.*

**CLINICAL CORRELATION**

**Urinary Bladder and Pelvic Peritoneum**

ATLAS 5.15, 5.23

As the urinary bladder fills, the peritoneal reflection from the anterior body wall to the urinary bladder is elevated above the level of the pubis, and the depth and breadth of the paravesical fossa and the rectovesical fossa will increase. A needle inserted just superior to the pubis (suprapubic access) can penetrate a filled urinary bladder without entering the peritoneal cavity. Sampling urine through direct collection in the bladder allows a physician to obtain a less contaminated sample for analysis than a transurethral sample obtained through catheterization.

8. Observe that the peritoneum covers the anterior surface of the inferior rectum (7).
9. Identify the **pararectal fossa** (paired), the shallow depressions in the peritoneal cavity on the lateral sides of the rectum (**8**).
10. Follow the peritoneum superiorly along the posterior aspect of the pelvic cavity and observe that forms the sigmoid mesocolon at the level of the third sacral vertebra.

## Section of the Male Pelvis

ATLAS 5.15, 5.16A, 5.48; VIDEO 5.4.2

***Dissection Note:*** The pelvis will be divided in the midline up to vertebral level L3 with a saw. Subsequently, the left side of the body will be transected at vertebral level L3 enabling removal of the left lower limb and the left hemi pelvis. The right lower limb and right side of the pelvis will remain attached to the trunk.

1. Refer to FIGURE 5.20A.
2. In the male pelvic cavity, make a midline cut beginning posterior to the pubic symphysis through the superior surface of the urinary bladder (**Cut 1**). Spread open the bladder and sponge the interior if necessary.
3. Identify the internal urethral orifice in the bladder and insert a probe into it. Use the probe as a guide to continue the midline cut inferior to the urinary bladder to divide the prostatic urethra and the prostate gland.
4. Extend the midline cut in the posterior direction cutting through the anterior and posterior walls of the rectum and the distal part of the sigmoid colon (**Cut 2**).
5. Clean the internal aspect of the rectum and anal canal. *Use caution when cleaning and moving fecal matter. Refer to your instructor for proper safety techniques.*
6. Use a scalpel to cut the left common iliac vein, left common iliac artery, left testicular vessels, and left ureter about 1 cm distal to their respective points of origin (**Cuts 3**).
7. Cut through the left lumbar arteries at vertebral levels L4 and L5 and reflect the abdominal aorta to the right side of the abdominal cavity.
8. Use a scalpel to make an incision through the muscles of the left lateral abdominal wall about 2 cm superior to the iliac crest through the musculature of the body wall and cut medially to the vertebral column (**Cut 4**).
9. Cut through the nerves of the left lumbar plexus at the point they cross the horizontal incision through the body wall and cut through any remaining fibers of the left psoas major and quadratus lumborum muscles at vertebral level L3.
10. Refer to FIGURE 5.20B.
11. In the perineum, use a scalpel blade to make a cut in the midline between the halves of the bulb of the penis from the pubic symphysis to the coccyx passing through the perineal membrane, perineal body, and anal canal (**Cut 5**).
12. Refer to FIGURE 5.20C.
13. With the cadaver in the supine position, use a saw to cut through the pubic symphysis in the midline from anterior to posterior (**Cut 6**), stopping at the inferior border of the pubic symphysis.
14. Turn the cadaver 90° to the right, so it is lying on its right side and prop the cadaver, or have your lab partners hold the body, so it does not fall or rotate.
15. Have your lab partners abduct the left lower limb to facilitate the sectioning of the sacrum.
16. Cut through the sacrum from posterior to anterior (**Cut 7**), making an effort not to allow the saw to pass between the soft tissue structures that were cut with the scalpel, retracting them out of the path of the blade if necessary.

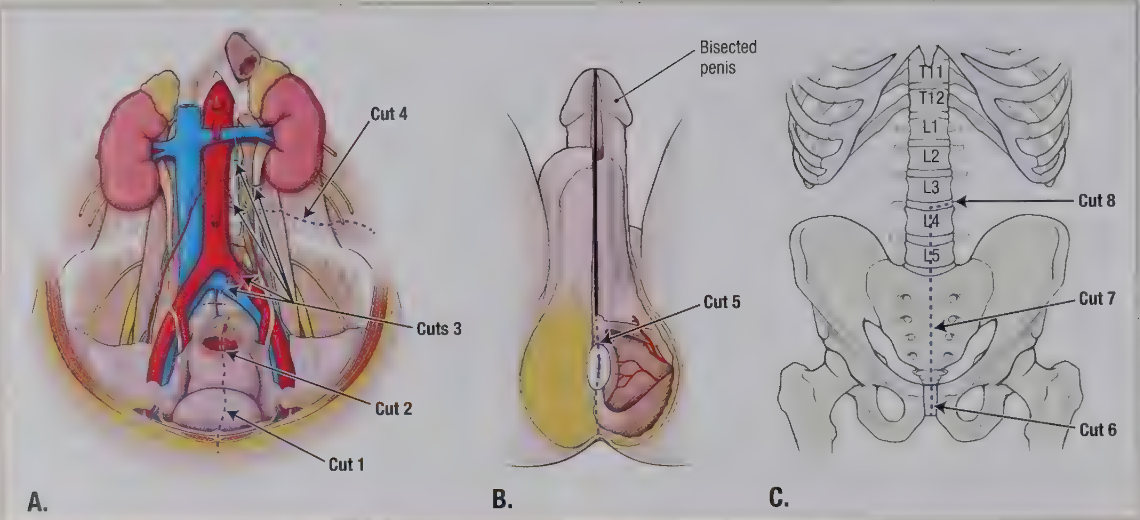

Cut 4
Cuts 3
Cut 2
Cut 1
A.
Bisected penis
Cut 5
B.
T11
T12
L1
L2
L3
L4
L5
Cut 8
Cut 7
Cut 6
C.

FIGURE 5.20 ● **A.** Soft tissue cuts for male pelvic bisection. Anterior view. **B.** Perineal cuts for male pelvic bisection. Inferior view. **C.** Skeletal cuts for male pelvic bisection and left lower limb and pelvis detachment. Anterior view.

17. Forcibly spread apart the lower limbs to expand the opening division of the sacrum and extend the midline cut as far superiorly as the body of the third lumbar vertebra.
18. Adduct the left lower limb and use the saw to cut horizontally through the left half of the intervertebral disc between L3 and L4 (**Cut 8**), sparing the inferior aspect of the abdominal aorta.
19. Once the horizontal and vertical cuts are connected, return the cadaver to the supine position.
20. Cut any remaining pieces of tissue preventing the left lower limb from being removed and pull the left lower limb away from the rest of the cadaver.
21. Clean the rectum and anal canal on both sides of the bisected pelvic specimen.

## Male Internal Genitalia

ATLAS 5.15, 5.16, 5.22; VIDEO 5.4.3

1. Refer to FIGURE 5.21.
2. Identify the **perineal membrane** deep to the bulb of the penis. *Note that the perineal membrane can be identified as a thin line at the deep edge of the bulb of the penis.*

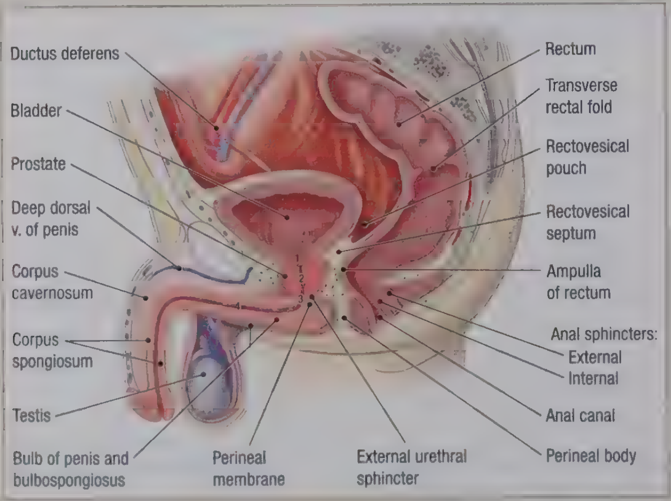

Ductus deferens
Bladder
Prostate
Deep dorsal v. of penis
Corpus cavernosum
Corpus spongiosum
Testis
Bulb of penis and bulbospongiosus
Perineal membrane
External urethral sphincter
Rectum
Transverse rectal fold
Rectovesical pouch
Rectovesical septum
Ampulla of rectum
Anal sphincters:
External
Internal
Anal canal
Perineal body
1
2
3
4

FIGURE 5.21 ● Midline section of the male pelvis. Midsagittal view.

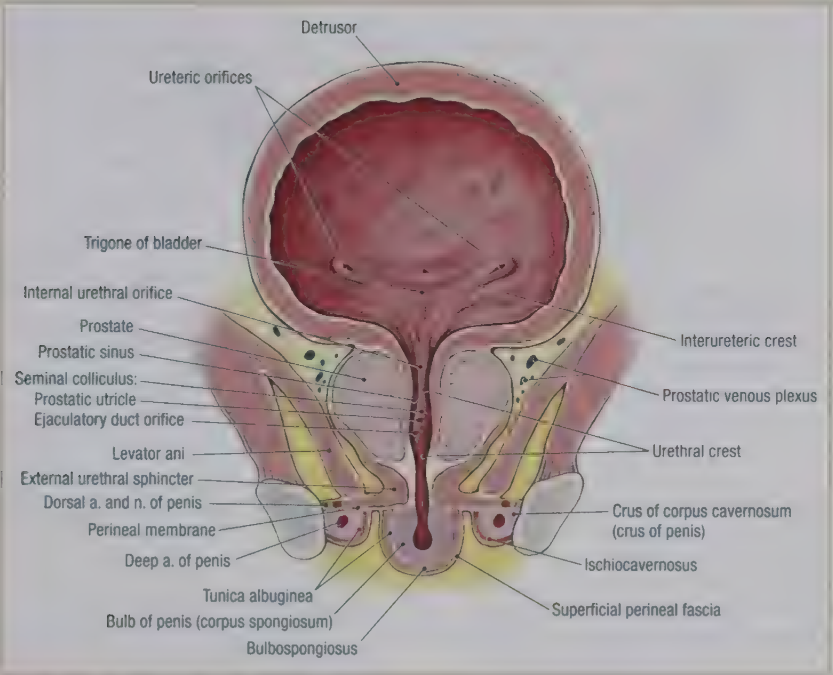

Detrusor
Ureteric orifices
Trigone of bladder
Internal urethral orifice
Prostate
Prostatic sinus
Seminal colliculus:
Prostatic utricle
Ejaculatory duct orifice
Levator ani
External urethral sphincter
Dorsal a. and n. of penis
Perineal membrane
Deep a. of penis
Tunica albuginea
Bulb of penis (corpus spongiosum)
Bulbospongiosus
Interureteric crest
Prostatic venous plexus
Urethral crest
Crus of corpus cavernosum
(crus of penis)
Ischiocavernosus
Superficial perineal fascia

FIGURE 5.22 ▪ Coronal section of the male urinary bladder and proximal urethra. Anterior view.

3. Superior (deep) to the perineal membrane, identify the **external urethral sphincter muscle** surrounding the **membranous urethra**. *Note that the external urethral sphincter muscle may be difficult to see in the sectioned specimen.*
4. On the sectioned pelvis, identify the four parts of the urethra: **preprostatic urethra (1)**, **prostatic urethra (2)**, **membranous urethra (3)**, and **spongy urethra (4)**.
5. Examine the **interior of the prostatic urethra** and observe that it is about 3 cm in length and passes through the prostate gland.
6. Refer to FIGURE 5.22.
7. Identify the longitudinal ridge of the **urethral crest** on the posterior wall of the prostatic urethra in the midline.
8. Make an effort to identify the **seminal colliculus**, an enlargement of the urethral crest, in the specimen and observe the presence of the **prostatic sinuses** on either side.
9. On the surface of the seminal colliculus, identify the **prostatic utricle**, the small opening in the midline.
10. On either side of the prostatic utricle, identify the **openings of the ejaculatory ducts**.
11. Refer to FIGURE 5.23.
12. Near the inner surface of the anterior abdominal wall, find the **ductus deferens** where it passes through the **deep inguinal ring** lateral to the inferior epigastric vessels.
13. Use blunt dissection to break through the peritoneum near the deep inguinal ring and peel the peritoneum off the lateral wall of the pelvic cavity from lateral to medial.
14. Detach the peritoneum at the point of reflection between the rectum and urinary bladder and place it in the tissue container.
15. Identify the **femoral ring** medial to the **external iliac vessels** passing inferior (deep) to the inguinal ligament.
16. Use blunt dissection to trace the ductus deferens from the deep inguinal ring toward the midline of the pelvis and observe that the ductus deferens passes superior and then medial to the branches of the internal iliac artery and superior to the ureter.
17. Trace the ductus deferens into the rectovesical septum, the endopelvic fascia between the rectum and the urinary bladder, and observe that the ductus deferens is in contact with the fundus (posterior surface) of the **urinary bladder**.
18. Identify the **ampulla of the ductus deferens**, the enlarged portion just before its termination.

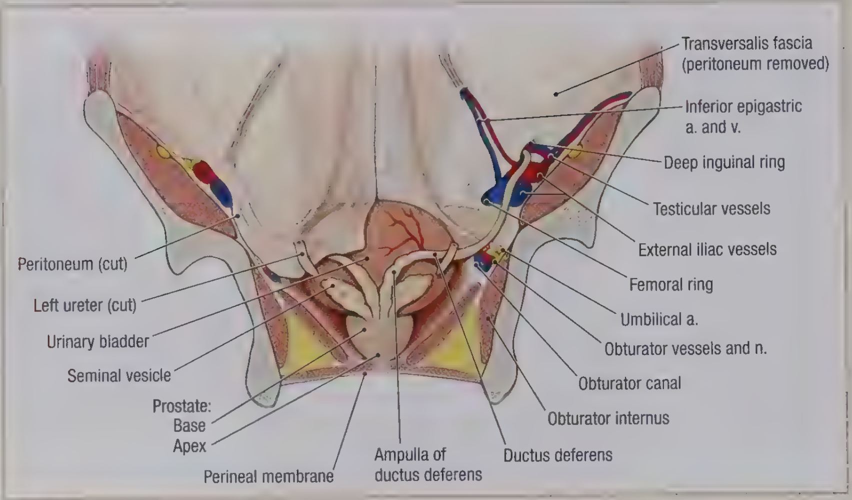

Transversalis fascia (peritoneum removed)
Inferior epigastric a. and v.
Deep inguinal ring
Testicular vessels
External iliac vessels
Femoral ring
Umbilical a.
Obturator vessels and n.
Obturator canal
Obturator internus
Ductus deferens
Ampulla of ductus deferens
Perineal membrane
Prostate:
Base
Apex
Seminal vesicle
Urinary bladder
Left ureter (cut)
Peritoneum (cut)

FIGURE 5.23 ● Male urinary bladder and internal genitalia with removed peritoneum (*right*). Posterior view.

19. Identify the **seminal vesicle** located inferolateral to the ampulla of the ductus deferens in the rectovesical septum posterior to the bladder. *Note that the duct of the seminal vesicle joins the ductus deferens to form the **ejaculatory duct** close to the prostate.*
20. Use blunt dissection to release the seminal vesicle from the rectovesical septum. Pay attention because the ejaculatory duct is delicate and easily torn where it enters the prostate. *Note that the ejaculatory ducts empty into the prostatic urethra from their openings on the seminal colliculus.*
21. Inferior to the urinary bladder, identify the **prostate**.
22. Observe that the **apex** of the prostate is directed inferiorly and that the **base** of the prostate is located superiorly against the neck of the urinary bladder.

## Dissection Follow-up

1. Review the position of the male pelvic viscera within the lesser pelvis and compare it to the position of the viscera in the female cadaver.
2. Review the peritoneum in the pelvic cavity and describe the differences in the male and female peritoneum.
3. Follow the ductus deferens from the epididymis to the ejaculatory duct, recalling its relationships to vessels, nerves, the ureter, and the seminal vesicle along this path.
4. Visit a dissection table with a female cadaver and follow the round ligament of the uterus from the labium majus to the uterus and compare this route to the course of the ductus deferens in the male pelvis.
5. Return the reflected tissue in the right hemipelvis back to anatomical position.
6. Return left lower limb and hemisected pelvis back to anatomical position.

# MALE URINARY BLADDER, RECTUM, AND ANAL CANAL

## Dissection Overview

The urinary bladder is a reservoir for the urine produced in the kidneys. When empty, the urinary bladder lies within the pelvic cavity. When full, the urinary bladder extends superiorly into the abdominal cavity. Organs located inferior to the peritoneum are classified as subperitoneal organs and are surrounded by endopelvic fascia. The urinary bladder and lower two-thirds of the rectum are subperitoneal, whereas the upper third of the rectum is partially covered by peritoneum.

Between the pubic symphysis and the urinary bladder is a potential space called the retropubic space (prevesical space). The retropubic space is filled with fat and loose connective tissue to accommodate the expansion of the urinary bladder. The inferior limit of the retropubic space is defined by the puboprostatic ligament, a condensation of fascia that ties the prostate to the inner surface of the pubis.

The order of dissection will be as follows: The parts of the urinary bladder will be studied. The interior of the urinary bladder will be studied. The interior of the rectum and anal canal will be studied.

## Dissection Instructions

### Male Urinary Bladder

ATLAS 5.23; VIDEO 5.5.1

1. Refer to FIGURE 5.24.
2. Begin the identification of the **parts of the urinary bladder** with the **apex**, the pointed part directed toward the anterior abdominal wall and identified by the attachment of the urachus.
3. The **body of the urinary bladder** is located between the apex and the **fundus**. The fundus of the bladder is the inferior part of the posterior wall, also called the **base of the urinary bladder**. Observe that in the male, the fundus is related to the ductus deferens, seminal vesicles, and rectum.
4. Identify the **neck of the urinary bladder**, the portion where the urethra exits the urinary bladder and the wall thickens to form the internal urethral sphincter. *Note that the internal urethral sphincter is positioned at the junction of the urinary bladder and the urethra and is an involuntary muscle controlled by the autonomic nervous system.*

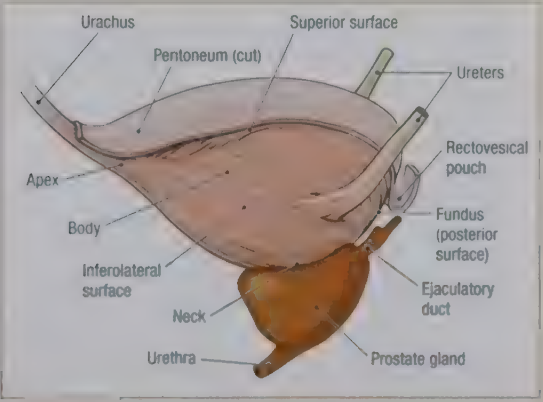


FIGURE 5.24 ● Parts of the male urinary bladder. Lateral view.

5. Observe that the **superior surface of the urinary bladder** is covered by peritoneum, whereas the **posterior surface** is covered by peritoneum on its superior part and by the endopelvic fascia of the rectovesical septum on its inferior part.
6. Verify that the **inferolateral** (paired) surface of the urinary bladder is covered by endopelvic fascia and lies deep to the reflection point of the peritoneum.
7. Refer back to FIGURE 5.22.
8. Examine the **wall of the urinary bladder** noting its thickness and observe that it consists of bundles of smooth muscle called **detrusor muscle**. *Note that the mucous membrane lining the majority of the inner surface of the urinary bladder lies in folds when the bladder is empty but will flatten out to accommodate expansion.*
9. Study the inner surface of the fundus and identify the **trigone of the urinary bladder (urinary trigone)**, a smooth, triangular region of mucous membrane defined by lines between the **internal urethral orifice** and the two **ureteric orifices**. *Note that the urinary trigone has now been bisected.*
10. Observe that the internal urethral orifice is located at the most inferior point in the urinary bladder at the inferior aspect of the trigone.
11. Identify the **interureteric crest**, a visible horizontal ridge extending between the orifices of the ureters.
12. Insert the tip of a probe into the orifice of the ureter and observe that the ureter passes through the muscular wall of the urinary bladder in an oblique direction. When the urinary bladder is full (distended), the pressure of the accumulated urine flattens the part of the ureter within the wall of the bladder and thus prevents reflux of urine into the ureter.
13. Find the ureter where it crosses the external iliac artery, or the bifurcation of the common iliac artery, and use blunt dissection to follow the ureter to the fundus of the urinary bladder.

## Male Rectum and Anal Canal

ATLAS 5.15A, 5.16; VIDEO 5.5.2

1. Refer back to FIGURE 5.21 and FIGURE 5.25.
2. Identify the **rectum** at its point of origin at the level of the third sacral vertebra.
3. On the sectioned pelvis, observe that the rectum follows the curvature of the sacrum.
4. Identify the **ampulla of the rectum**, the dilated portion of the rectum just proximal to the point where the rectum bends approximately 80° posteriorly (anorectal flexure). Observe that the ampulla is continuous with the anal canal.
5. Identify the prostate gland and seminal vesicles and observe that they are located adjacent to the anterior wall of the rectum.
6. Examine the inner surface of the rectum and observe that the mucous membrane is smooth except for the presence of **transverse rectal folds**, usually one on the right side of the rectum and two on the left side. *Note that the transverse rectal folds may be difficult to identify in some cadavers.*
7. Observe that the **anal canal** is only 2.5 to 3.5 cm in length and passes out of the pelvic cavity and into the anal triangle of the perineum.

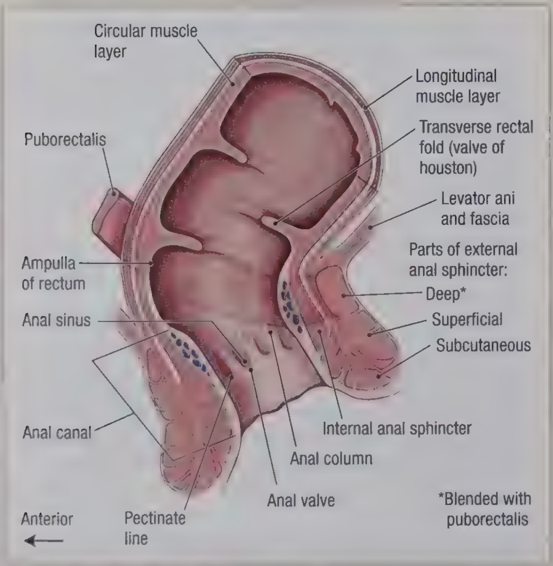


FIGURE 5.25 ■ Distal rectum, anal sphincters, and anal canal. Midsagittal view.

CLINICAL CORRELATION

### Benign Prostatic Hypertrophy and Digital Rectal Examination

ATLAS 5.24C

The prostate continues to grow throughout life in a condition known as benign prostatic hypertrophy (BPH). BPH can cause partial or total obstruction of the urethral orifice or the prostatic urethra, and lead to urgency (a sudden desire to urinate), nocturia (needing to void during the night), and dysuria (difficult or painful urination). BPH may also cause infections or enlargement of the urinary bladder or kidneys, or erectile dysfunction. The size and consistency of the prostate, in particular the posterior lobe (the most common location of prostate cancer), can be assessed by palpation through the anterior wall of the rectum by a digital rectal examination (DRE).

8. Examine the inner surface of the anal canal and identify the **anal columns**, 5 to 10 longitudinal ridges of mucosa in the proximal part of the anal canal. The anal columns contain branches of the **superior rectal artery** and **vein**. *Note that the mucosal features of the anal canal may be difficult to identify in older individuals.*
9. Identify the semilunar folds of mucosa forming the **anal valves**, which unite the distal ends of the anal columns. Between the anal valve and the wall of the anal canal is a small pocket called an **anal sinus**.
10. Identify the **pectinate line**, the irregular line formed by the contour of the collective anal valves.
11. Identify the **external anal sphincter muscle** in the sectioned specimen surrounding the anal canal. *Note that the external anal sphincter is composed of skeletal muscle and is under voluntary control.*
12. Identify the **internal anal sphincter muscle** in the sectioned specimen surrounding the anal canal. *Note that the internal anal sphincter is composed of smooth muscle and is under involuntary control.*
13. Observe that the longitudinal muscle of the anal canal separates the two sphincter muscles. If you have difficulty identifying the anal sphincters, use a scalpel to cut another section through the wall of the anal canal to improve the clarity of the dissection.

## Dissection Follow-up

1. Use the dissected specimen to review the features of the urinary bladder, rectum, and anal canal.
2. Review the relationships of the seminal vesicles, ampulla of the ductus deferens, and ureters to the rectum and fundus of the urinary bladder.
3. Visit a dissection table with a female cadaver and review the relationships of the uterus, vagina, and ureters to the rectum and fundus of the urinary bladder.
4. Review the kidney, the abdominal course of the ureter, the pelvic course of the ureter, and the function of the urinary bladder as a storage organ.
5. Review the male urethra and compare it with the female urethra.
6. Review all parts of the large intestine and recall its function in absorption of water and in compaction and elimination of fecal material.
7. Compare muscle type and innervation of the external and internal anal sphincters.
8. Return all reflected tissue back to anatomical position.

# MALE INTERNAL ILIAC ARTERY AND SACRAL PLEXUS

## Dissection Overview

Anterior to the sacroiliac articulation, the common iliac artery divides to form the external and internal iliac arteries. The external iliac artery distributes to the lower limb, and the internal iliac artery distributes to the pelvis. The internal iliac artery commonly divides into an anterior division and a posterior division. Branches arising from the anterior division are mainly visceral and supply the urinary bladder, internal genitalia, external genitalia, rectum, and gluteal region. Branches arising from the posterior division are parietal and supply the pelvic walls and gluteal region.

The somatic plexuses of the pelvic cavity, the sacral plexus and the coccygeal plexus, are located between the pelvic viscera and the lateral pelvic wall embedded in the endopelvic fascia. These somatic nerve plexuses are formed by contributions from anterior rami of spinal nerves L4–Co1. The primary visceral nerve plexus of the pelvic cavity is the inferior hypogastric plexus (pelvic plexus), formed by contributions from the hypogastric nerves, sacral splanchnic nerves (sympathetic), and pelvic splanchnic nerves (parasympathetic).

The order of dissection will be as follows: The branches of the posterior division of the internal iliac artery will be identified. The branches of the anterior division of the internal iliac artery will be identified. The nerves of the sacral plexus will be dissected. Subsequently, the pelvic portion of the sympathetic trunk will be dissected.

## Dissection Instructions

### Male Pelvic Blood Vessels

ATLAS 5.26, 5.27; VIDEO 5.6.1

***Dissection Note:*** The internal iliac artery has one of the most variable branching patterns of any artery, and it is worth noting at the outset of this dissection that you must use the target distribution of the branches to identify them, not their pattern of branching or point of origin.

The dissection of the pelvic vasculature may be performed on both the right and left sides of the hemisected pelvis; however, it is recommended to focus the dissection on just the right side because a deeper dissection will be performed on the left side with the detached lower limb.

1. Refer to FIGURE 5.26.
2. Identify the **internal iliac vein** and observe that its tributaries largely parallel the nearby arteries but are plexiform in nature. To clear the dissection field, remove all tributaries to the internal iliac vein as each correlating artery is identified and cleaned.
3. Identify the locations of the **prostatic venous plexus**, **vesical venous plexus**, and **rectal venous plexus**, all of which drain into the internal iliac vein.
4. On the dissected specimen, identify the **deep dorsal vein of the penis** just inferior to the pubic symphysis and verify that it empties into the prostatic venous plexus.
5. Identify and clean the **common iliac artery** and follow it distally until it bifurcates into the **external iliac artery** and the **internal iliac artery**.
6. Use blunt dissection to follow the internal iliac artery into the pelvis and observe that it gives numerous smaller vessels from two major divisions, anterior and posterior.
7. Begin identification of the branches of the posterior division of the internal iliac artery by finding the most posterior and superior branch, the **iliolumbar artery**.
8. Observe that the **iliolumbar artery** passes posteriorly from the posterior division and then ascends lateral

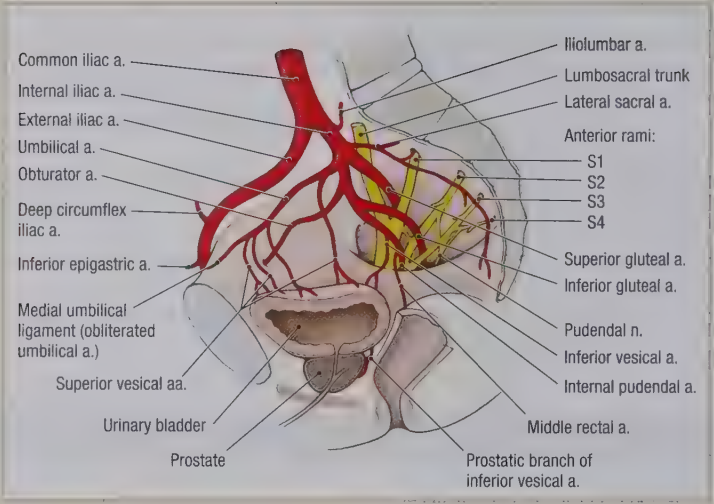

Common iliac a.
Internal iliac a.
External iliac a.
Umbilical a.
Obturator a.
Deep circumflex iliac a.
Inferior epigastric a.
Medial umbilical ligament (obliterated umbilical a.)
Superior vesical aa.
Urinary bladder
Prostate
Iliolumbar a.
Lumbosacral trunk
Lateral sacral a.
Anterior rami:
S1
S2
S3
S4
Superior gluteal a.
Inferior gluteal a.
Pudendal n.
Inferior vesical a.
Internal pudendal a.
Middle rectal a.
Prostatic branch of inferior vesical a.

**FIGURE 5.26** ● Branches of the male internal iliac artery. Midsagittal view.

to the **sacral promontory**, lumbar vertebrae, lumbosacral trunk, and the obturator nerve.

9. Identify the **lateral sacral artery**, which gives rise to a superior branch and an inferior branch.
10. Observe that the inferior branch passes anterior to the sacral ventral rami. *Note that the lateral sacral artery may arise from a common trunk with the iliolumbar artery.*
11. Identify the last and typically largest branch of the posterior division, the **superior gluteal artery**, which exits the pelvic cavity through the greater sciatic foramen superior to the piriformis muscle.
12. Identify the branches of the **anterior division of the internal iliac artery** beginning with the **umbilical** artery. In the medial umbilical fold, find the **medial umbilical ligament** (the remnant of the umbilical artery) and use blunt dissection to trace it posteriorly to the umbilical artery.
13. Identify and clean several **superior vesical arteries**, which arise from the inferior surface of the umbilical artery and descend to the superolateral part of the urinary bladder.
14. Inferior to the umbilical artery, identify the **obturator artery**, which passes into the obturator canal along with the **obturator nerve**. Find the obturator artery where it enters the obturator canal in the lateral wall of the pelvis and follow the artery posteriorly to its origin. *Note that the obturator artery arises from the external iliac or inferior epigastric arteries in about a quarter of individuals. This aberrant obturator artery crosses the pelvic brim to enter the obturator canal and is particularly at risk of injury during surgical repair of a femoral hernia.*
15. Follow the anterior division of the internal iliac artery toward the pelvic floor and identify the **inferior gluteal artery**.
16. Observe that the inferior gluteal artery commonly passes out of the pelvic cavity into the gluteal region through the greater sciatic foramen inferior to the piriformis muscle. *Note that the inferior gluteal artery may share a common trunk with the internal pudendal artery or, less commonly, with the superior gluteal artery.*
17. Identify the **inferior vesical artery** off the anterior aspect of the anterior division of the internal iliac artery. Observe that the inferior vesical artery courses toward the fundus of the urinary bladder to supply the bladder, seminal vesicle, and prostate. *Note that the inferior vesical artery is a named branch only in the male; in the female, it is an unnamed branch of the vaginal artery.*
18. Identify the **middle rectal artery** coursing medially toward the rectum. The middle rectal artery often arises from a common trunk with the inferior vesical artery, making positive identification difficult. *Note that the middle rectal artery, like the inferior vesical artery, sends branches to the seminal vesicle and prostate.*
19. Identify the **internal pudendal artery** anterior to the inferior gluteal artery. Observe that the internal pudendal artery exits the pelvic cavity by passing out of the greater sciatic foramen. In the gluteal region the internal pudendal artery will then course posterior to the sacrospinous ligament to enter the lesser sciatic foramen to reach the perineum. *Note that the internal pudendal artery often arises from a common trunk with the inferior gluteal artery.*

## Male Pelvic Nerves

ATLAS 5.12A, 5.13, 5.29; VIDEO 5.6.2

***Dissection Note:*** The dissection of the pelvic nerves may be performed on both the right and left sides of the hemisected pelvis; however, it is recommended to focus the dissection on just the right side because a deeper dissection will be performed on the left side with the detached lower limb.

1. Refer to FIGURE 5.27.
2. Use blunt dissection to free the rectum from the anterior surface of the sacrum and coccyx.
3. Retract the rectum medially and identify the **sacral plexus** of nerves. Observe that the sacral plexus is closely related to the anterior surface of the piriformis muscle.
4. Just lateral to the sacral promontory, identify and clean the **lumbosacral trunk** (anterior rami of L4 and L5) and verify that it joins the sacral plexus.
5. Inferior to the lumbosacral trunk, identify the anterior rami of S2 and S3, which emerge between the proximal attachments of the piriformis muscle.
6. Identify the **sciatic nerve** and observe that it is formed by the anterior rami of spinal nerves L4–S3. The sciatic nerve exits the pelvis by passing through the greater sciatic foramen to enter the gluteal region, usually inferior to the piriformis muscle.
7. Observe that the **superior gluteal artery** usually passes between the **lumbosacral trunk** and the **anterior ramus of spinal nerve S1** and exits the pelvis through the greater sciatic foramen, passing superior to the piriformis muscle.
8. Observe that the **inferior gluteal artery** usually passes between the anterior rami of spinal nerves S2 and S3, but may pass between the anterior rami S1 and S2, to exit the pelvis inferior to the piriformis muscle.
9. Identify the **pudendal nerve** and observe that it is formed by contributions from the anterior rami of spinal nerves S2, S3, and S4. *Note that the pudendal nerve exits the pelvis by passing inferior to the piriformis muscle, through the greater sciatic foramen. The pudendal nerve then enters the perineum by passing through the lesser sciatic foramen.*
10. Identify the **pelvic splanchnic nerves (nervi erigentes)**. Observe that pelvic splanchnic nerves arise from the anterior rami of spinal nerves S2, S3, and S4. *Note that pelvic splanchnic nerves carry presynaptic parasympathetic axons for innervation of pelvic organs and the distal gastrointestinal tract from the left colic flexure to the anal canal.*
11. Identify the **sacral portion of the sympathetic trunk** located on the anterior surface of the sacrum, medial to the ventral sacral foramina. Observe that the **sympathetic trunk** continues from the abdominal region into the pelvis and that the two sides join in the midline near the level of the coccyx to form the **ganglion impar**.
12. Identify the **gray rami communicantes**, which connect the sympathetic ganglia to the sacral anterior rami. *Note that each gray ramus communicans carries postsynaptic sympathetic fibers to an anterior ramus for distribution to the lower extremity and perineum.*

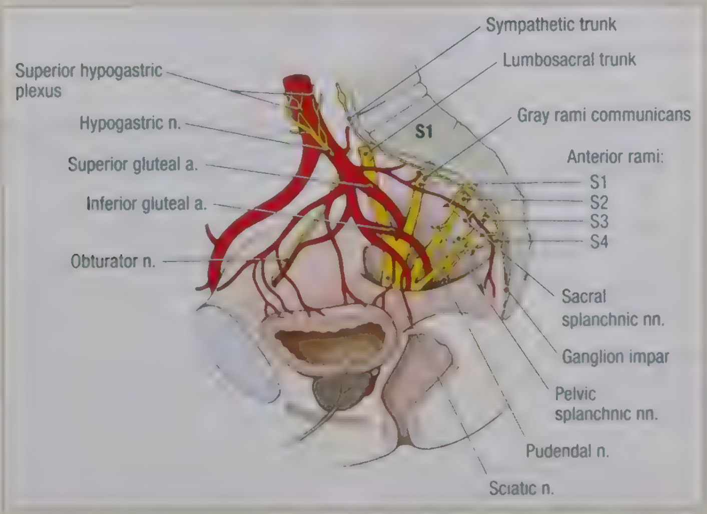


FIGURE 5.27 ■ Sacral and autonomic nerve plexuses in the male. Midsagittal view.

13. Identify the **sacral splanchnic nerves** arising from two or three of the sacral sympathetic ganglia and observe that they pass directly to the **inferior hypogastric plexus**. *Note that sacral splanchnic nerves carry sympathetic fibers that distribute to the pelvic viscera.*
14. On one side of the pelvic cavity, make an effort to follow the hypogastric plexus superiorly toward the condensation of the plexus into the **right** or **left hypogastric nerve**.
15. Identify the **superior hypogastric plexus** and review the origins of the autonomics in both the superior and inferior hypogastric plexuses.

CLINICAL CORRELATION

**Hypogastric Nerve Damage**

ATLAS 5.13, 5.29B

The inferior hypogastric plexus is located in the endopelvic fascia lateral to the rectum, bladder, seminal vesicles, and prostate. The inferior hypogastric plexus, as well as its superior contribution of the hypogastric nerve, could be injured during pelvic surgery. Damage to the autonomic plexus could cause loss of bladder control and erectile dysfunction.

## Dissection Follow-up

1. Review the abdominal aorta and its terminal branches.
2. Use the dissected specimen to review the branches of the internal iliac artery and the region supplied by each branch.
3. Visit a dissection table with a female cadaver and review the arteries unique to the female (uterine artery and vaginal artery) and note their relationship to the ureter.
4. Review the formation of the sacral plexus and the branches dissected in the pelvis.
5. Review the course of the pudendal nerve from the pelvic cavity to the urogenital triangle.
6. Return all reflected tissue back to anatomical position.

# MALE PELVIC DIAPHRAGM

## Dissection Overview

The pelvic diaphragm is the muscular floor of the pelvic cavity and is formed by the levator ani muscle and coccygeus muscle as well as the fasciae covering their superior and inferior surfaces. The pelvic diaphragm extends from the pubic symphysis anteriorly to the coccyx posteriorly. Laterally, the pelvic diaphragm is attached to the fascia covering the obturator internus muscle. The urethra and anal canal pass through midline openings in the pelvic diaphragm called the urogenital hiatus and anal hiatus, respectively.

The order of dissection will be as follows: The pelvic viscera will be retracted medially. The obturator internus, tendinous arch of the levator ani, and the levator ani will be identified. The vas deferens, prostate, and anal canal will be cut and the pelvic viscera reflected.

## Dissection Instructions

***Dissection Note:*** Perform the following dissection sequence on only one side of the cadaver. If the left lower limb was removed during the bisection of the pelvis, it is recommended that this dissection be performed on the left side to preserve the continuity of the vasculature into the abdominal cavity on the right side.

### Male Pelvic Diaphragm

ATLAS 5.9, 5.11, 5.12; VIDEO 5.7.1

1. Refer to FIGURE 5.28A.
2. Retract the rectum, urinary bladder, prostate, and seminal vesicles medially and identify the **pelvic diaphragm**.
3. Use blunt dissection to remove any remaining fat and connective tissue from the superior surface of the pelvic diaphragm.
4. Locate the **obturator canal** piercing the obturator internus by identifying and following the obturator artery and nerve.
5. Palpate the medial surface of the ischial spine through the levator ani and identify the **tendinous arch of the levator ani muscle**. Observe that the tendinous arch lies just inferior to a line connecting the ischial spine and the obturator canal. *Note that the tendinous arch is the origin of part of the levator ani muscle.*

***Dissection Note:*** Identify the three components of the **levator ani muscle** by their anterolateral attachments. Learn, but do not dissect, their posterior attachments.

6. Refer to FIGURE 5.28B.
7. Identify the **puborectalis muscle** attaching anteriorly to the body of the pubis and posteriorly to the puborectalis muscle of the opposite side (in a midline raphe). The puborectalis muscles form the margin

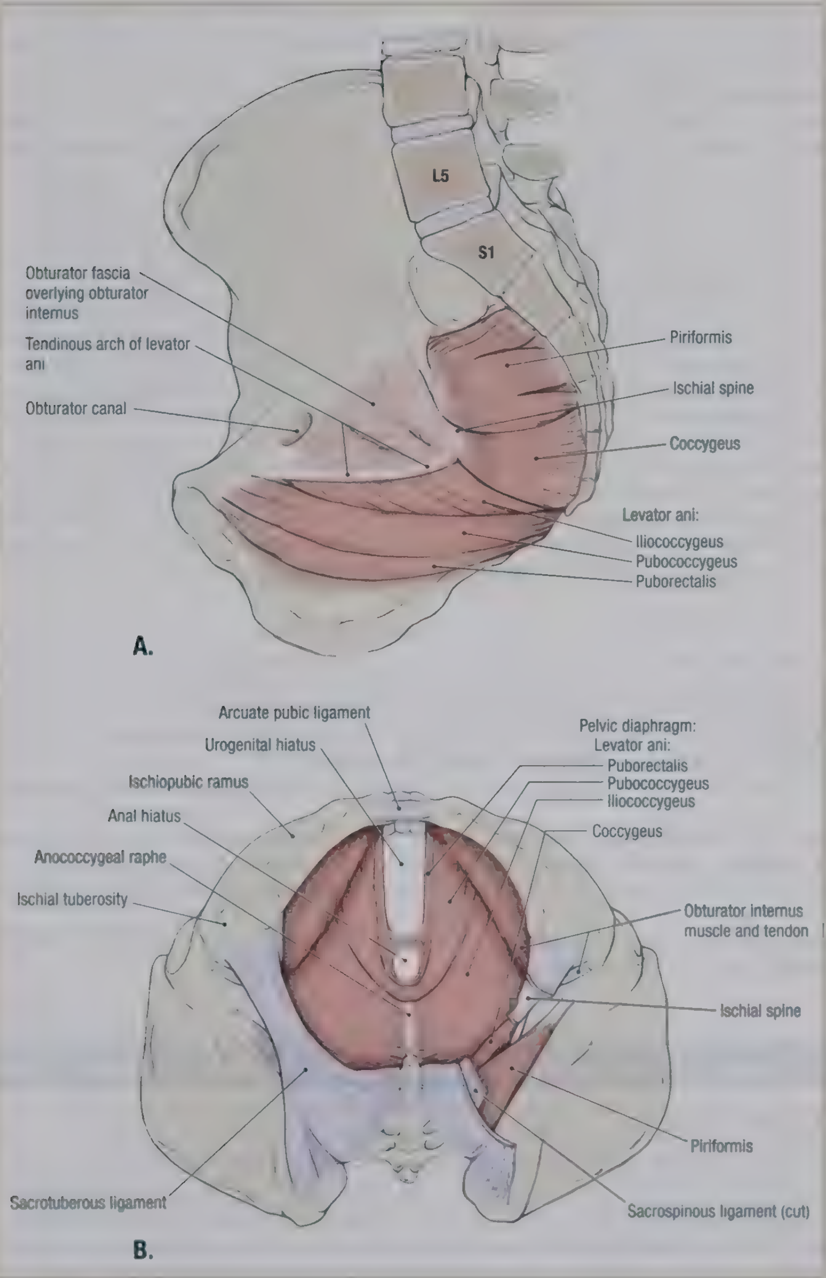

L5
S1
Obturator fascia overlying obturator internus
Tendinous arch of levator ani
Obturator canal
Piriformis
Ischial spine
Coccygeus
Levator ani:
Iliococcygeus
Pubococcygeus
Puborectalis
A.
Arcuate pubic ligament
Urogenital hiatus
Ischiopubic ramus
Anal hiatus
Anococcygeal raphe
Ischial tuberosity
Pelvic diaphragm:
Levator ani:
Puborectalis
Pubococcygeus
Iliococcygeus
Coccygeus
Obturator internus muscle and tendon
Ischial spine
Piriformis
Sacrotuberous ligament
Sacrospinous ligament (cut)
B.

FIGURE 5.28 ● Male pelvic diaphragm. **A.** Midsagittal view. **B.** Inferior view.

of the urogenital hiatus, and a "puborectal sling," which maintains the **anorectal flexure** of the rectum. *Note that during defecation, the puborectalis muscles relax, the anorectal flexure straightens, and the elimination of fecal matter is facilitated.*

8. Identify the **pubococcygeus muscle** attaching from the body of the pubis anteriorly to the coccyx and the **anococcygeal raphe (ligament)** posteriorly.
9. Identify the **iliococcygeus muscle** attaching from the tendinous arch anterolaterally to the coccyx and

the anococcygeal raphe posteriorly. *Note that the levator ani muscle supports the pelvic viscera and resists increases in intra-abdominal pressure.*

10. Identify the **coccygeus muscle**, which completes the pelvic diaphragm posteriorly. Observe that the anterior attachment of the coccygeus muscle is the ischial spine and that its posterior attachment is the lateral border of the coccyx and the lowest part of the sacrum.
11. Place the fingers of one hand in the ischioanal fossa inferior to the pelvic diaphragm and the fingers of the other hand on the superior surface of the pelvic diaphragm. Palpate the pelvic diaphragm between both hands and appreciate its thinness.
12. Turn the left lower limb and observe that the **obturator internus muscle** forms the lateral wall of the ischioanal fossa and perineum inferior to the pelvic diaphragm and the lateral wall of the pelvic cavity superior to the pelvic diaphragm.

***Dissection Note:*** The medial attachment of the obturator internus muscle is the margin of the obturator foramen and inner surface of the obturator membrane. The lateral attachment of the obturator internus muscle is the greater trochanter of the femur and will be studied when the gluteal region is dissected.

13. Observe that the urethra and anal canal pass through midline openings in the pelvic diaphragm called the **urogenital hiatus** and **anal hiatus**, respectively.
14. To increase the visibility of the pelvic diaphragm, cut the **vas deferens** a few centimeters away from the deep inguinal ring and reflect it along with the pelvic viscera medially.
15. If the muscles forming the pelvic diaphragm remain difficult to see, make an incision through the inferior aspect of the prostate and anal canal and detach the viscera from the pelvic floor. Leave the viscera attached to the neurovascular structures, so the relationships are maintained for later review.
16. Review the general pattern of lymphatic drainage of the pelvis and identify the location of the **common iliac** nodes, the **external iliac nodes**, the **internal iliac nodes**, the **sacral nodes**, and the **lumbar nodes**.

## Dissection Follow-up

1. Review the proximal attachment and action of each muscle of the pelvic diaphragm.
2. Review the relationship of the branches of the internal iliac artery to the pelvic diaphragm.
3. Review the relationship of the sacral plexus to the pelvic diaphragm.
4. Review the role played by the pelvic diaphragm in forming the boundary between the pelvic cavity and the perineum.
5. Review the function of the pelvic diaphragm and perineal body in supporting the pelvic and abdominal viscera.
6. Compare the lymphatic drainage of the perineal contents to the lymphatic drainage of the testis.
7. Review the formation of the thoracic duct to complete your understanding of the lymphatic drainage from this region.
8. Visit a dissection table with a female cadaver and perform a complete review of the dissected female pelvis.
9. Return all reflected tissue back to anatomical position.

# FEMALE EXTERNAL GENITALIA, UROGENITAL TRIANGLE, AND PERINEUM

## Dissection Overview

If you dissected a male cadaver, use the remainder of this chapter for review with a female cadaver.

In the embryo, the male and female external genitalia have similar origins and remain morphologically similar until a certain stage in development. Thus, many of the structures of the external genitalia have a homologous counterpart in the opposite sex. The labium majus in the female is the homologue of the scrotum in the male. However, the labium majus contains both Camper's fascia and dartos fascia, unlike the scrotum, which only contains dartos.

The superficial perineal fascia has a superficial fatty layer and a deep membranous layer. In the female, the superficial fatty layer provides the shape of the labium majus and is continuous with the fat of the lower abdominal wall (Camper's fascia), ischioanal fossa, and thigh as shown in FIGURE 5.29. The membranous layer of the superficial perineal fascia (Colles' fascia) is attached to the ischiopubic ramus as far posteriorly as the ischial tuberosity and to the posterior edge of the perineal membrane. The membranous layer of the superficial perineal fascia forms the superficial boundary of the superficial perineal pouch (space).

The membranous layer of superficial perineal fascia (Colles' fascia) is continuous with the membranous layer of superficial fascia of the lower abdominal wall (Scarpa's fascia). The membranous layer of the superficial perineal fascia is

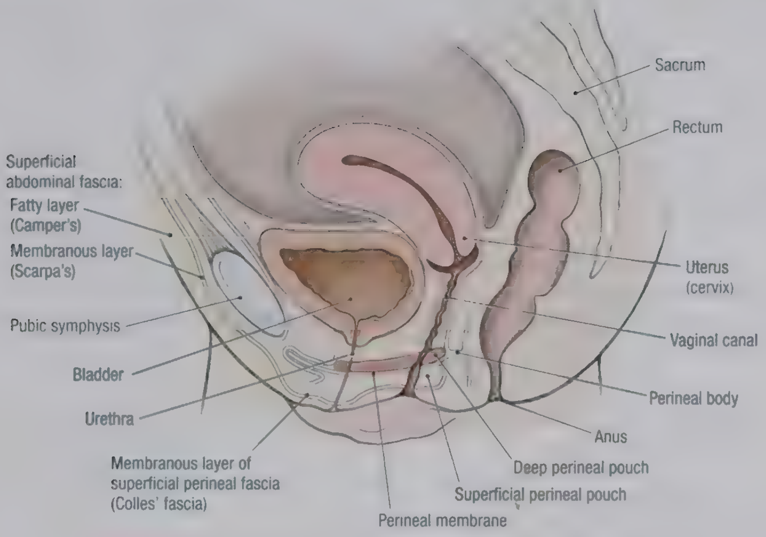

Sacrum
Rectum
Superficial abdominal fascia:
Fatty layer (Camper's)
Membranous layer (Scarpa's)
Pubic symphysis
Bladder
Urethra
Membranous layer of superficial perineal fascia (Colles' fascia)
Uterus (cervix)
Vaginal canal
Perineal body
Anus
Deep perineal pouch
Superficial perineal pouch
Perineal membrane

FIGURE 5.29 ● Fasciae of the female perineum. Midsagittal view.

attached along the posterior border of the perineal membrane. The labium majus of the female does not have the layer of dartos muscle as seen in the male scrotum but rather contains a layer of Camper's fascia.

The order of dissection of the female urogenital triangle will be as follows: The round ligament of the uterus will be followed from the superficial inguinal ring for a short distance into the superior part of the labium majus. The external genitalia will be examined. The skin will be removed from the labia majora. The superficial perineal fascia will be removed, and the contents of the superficial perineal pouch will be identified. The contents of the deep perineal pouch will be described but only minimally dissected.

## Skeletal Anatomy

Refer to an articulated bony pelvis and identify the following skeletal features.

### *Skeleton of the Female Pelvis*

ATLAS 5.3A, 5.6, 5.8A

1. Refer to FIGURE 5.30.
2. Identify the three bones comprising the hip bone: **pubis**, **ischium**, and **ilium**.
3. Orient the bony pelvis in the **erect posture** (anatomical position) and observe that the **anterior superior iliac spines** and the anterior aspect of the pubis at the **pubic tubercles** are in the same coronal plane.
4. Observe that in anatomical position, the plane of the pelvic inlet forms an angle of approximately 55 to the horizontal.
5. On the anterior surface of the hip bone, identify the **iliac fossa**. Observe that the iliac fossae are directed toward one another and form the lateral boundaries of the **false (greater) pelvis**, the portion of the bony pelvis superior to the **pelvic (inlet) brim**.
6. Observe that the pelvic inlet is formed by the **sacral promontory** and **anterior border of the ala (wing) of the sacrum** posteriorly, the arcuate line of the ilium laterally, and the pecten pubis and pubic crest of the pubic bones anteriorly, which meet at the **pubic symphysis**.
7. Observe that the lesser pelvis is located inferior to the pelvic brim and surrounded by bone. *Note that the inferior boundary of the lesser pelvis is the pelvic diaphragm.*
8. Identify the **obturator foramen**, the large opening on the anterior aspect of the pelvis.
9. Observe that in anatomical position the obturator foramen faces inferiorly and is bound anteriorly by the **superior pubic ramus**, medially by the **ischiopubic ramus**, and laterally by the body of the **ischium**.
10. Observe that the ischiopubic ramus is formed by the **ischial ramus** and the **inferior pubic ramus**, often not easily delineated.
11. Compare a male and female bony pelvis and observe that the **subpubic angle** (angle of the pubic arch) is wider in females than in males.

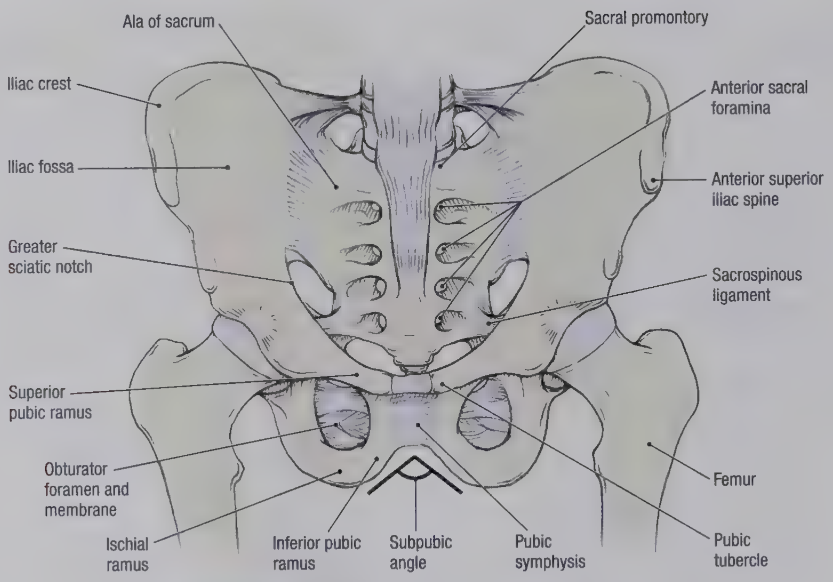

Ala of sacrum
Sacral promontory
Iliac crest
Anterior sacral foramina
Iliac fossa
Anterior superior iliac spine
Greater sciatic notch
Sacrospinous ligament
Superior pubic ramus
Obturator foramen and membrane
Femur
Ischial ramus
Inferior pubic ramus
Subpubic angle
Pubic symphysis
Pubic tubercle

FIGURE 5.30 ■ The female bony pelvis. Anterior view.

## Surface Anatomy

The surface anatomy of the abdomen may be studied on a living subject or on a cadaver. On the cadaver, note that fixation of tissue during embalming may make it difficult to distinguish bone from well-preserved soft tissues in some specimens.

### *Female Urogenital Triangle*

ATLAS 5.46; VIDEO 5.8.1

1. Refer to FIGURE 5.31.
2. Place the cadaver in the supine position. Stretch the thighs widely apart and brace them.
3. Examine the **vulva** (female external genitalia) inferior to the region of the **mons pubis**.
4. Observe that the mons pubis is the region of the female external genitalia anterior to the pubic symphysis filled with fat and covered with pubic hair.

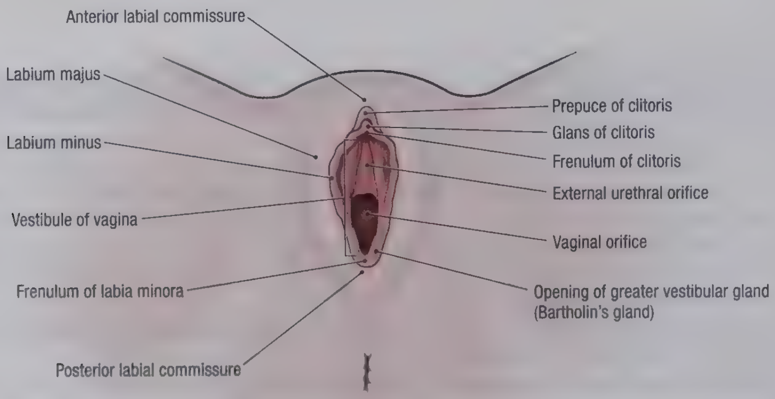

Anterior labial commissure
Labium majus
Labium minus
Prepuce of clitoris
Glans of clitoris
Frenulum of clitoris
External urethral orifice
Vestibule of vagina
Vaginal orifice
Frenulum of labia minora
Opening of greater vestibular gland (Bartholin's gland)
Posterior labial commissure

FIGURE 5.31 ■ Surface anatomy of the female external genitalia. Inferior view.

5. Identify the **labium majus (pl. labia majora)** and observe that the right and left sides meet anteriorly at the **anterior labial commissure** and posteriorly at the **posterior labial commissure** just anterior to the **frenulum of labia minora**. *Note that the labia majora are covered in hair and filled with fat.*
6. Just posterior to the anterior labial commissure, identify the **clitoris**.
7. Observe that the **glans** of the clitoris is covered by the **prepuce** on its dorsal surface, whereas the **frenulum of the clitoris** curves posteriorly for a short distance along the ventral surface. *Note that the glans, prepuce, and frenulum of the clitoris are analogous to the male counterparts on the penis except that they do not carry the urethra.*
8. Medial to the labia majora, identify the **labia minora** (sing. **labium minus**) and observe that unlike the labia majora, they are not covered with hair. *Note that the labia minora have numerous sebaceous glands and lie superficial to the bulbs of the vestibule.*
9. Identify the region of the **vestibule of the vagina** between the labia minora.
10. Within the vestibule, identify the small anteriorly located **external urethral orifice** and the larger and more posteriorly located **vaginal orifice**. *Note that within the vestibule, the* openings of the paraurethral ducts *are present on each side of the external urethral orifice, although it is unlikely that they will be visible in the cadaveric specimen.*

## Dissection Instructions

### Labium Majus (pl. Labia Majora)

ATLAS 5.2A, 5.46; VIDEO 5.8.2

***Dissection Note:*** The dissection of the labium majus corresponds to the dissection of the scrotum in male cadavers. Partner with a dissection team that has a male cadaver for the dissection of the external genitalia. You are expected to observe and learn the anatomy for both sexes.

1. Refer back to FIGURE 4.8C.
2. At the **superficial inguinal ring**, identify the **round ligament of the uterus**.
3. Use blunt dissection to demonstrate that the round ligament of the uterus emerges from the superficial inguinal ring and spreads out into the fatty tissue of the labium majus. *Note that the round ligament is a delicate structure that can be demonstrated for only 1 to 2 cm distal to the superficial inguinal ring.*

**CLINICAL CORRELATION**

**Lymphatic Drainage of the Labium Majus**

ATLAS 5.39

Lymphatics from the labium majus drain to the superficial inguinal lymph nodes. Inflammation of the labium majus may cause tender, enlarged superficial inguinal lymph nodes.

### Skin Incisions of the Female Urogenital Triangle

ATLAS 5.46; VIDEO 5.8.3

***Dissection Note:*** Partner with a dissection team that has a male cadaver for the dissection of the urogenital triangle to compare the two sexes. It is recommended to perform a partial-thickness skin removal technique leaving the subcutaneous tissue intact because cutting too deeply may easily damage many of the structures in the region. To facilitate dissection, position yourself between the thighs with the trunk of the cadaver pulled toward the end of the dissection table.

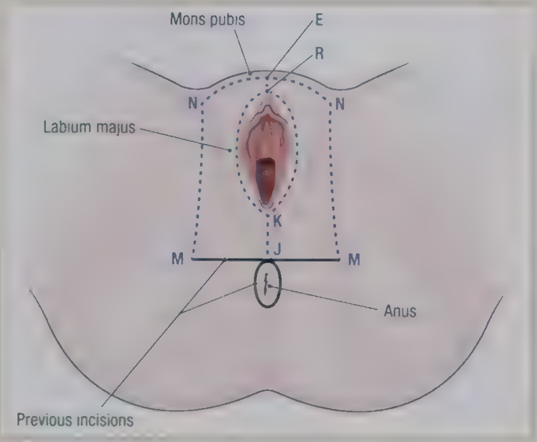


FIGURE 5.32 ● Skin incisions for the female perineum. Inferior view.

1. Refer to FIGURE 5.32.
2. With the cadaver in the supine position, stretch the thighs widely apart and brace them.
3. Make a skin incision in the midline from the anterior margin of the anus (J) to the posterior labial commissure (K).
4. Make a skin incision that follows the medial surface of the labium majus on each side beginning at the posterior labial commissure (K), passing lateral to the labium minus, and ending at the anterior labial commissure (R).
5. Make a skin incision in the midline from the anterior labial commissure (R) to the midline of the mons pubis (E).

6. Make a transverse incision across the mons pubis from the anterior aspect of the right thigh (N) to the anterior aspect of the left thigh (N). *Note that if the abdomen was previously dissected, a portion of this incision was already made.*
7. Make a skin incision connecting from the anterior aspect of each thigh (N) posteriorly to a point in the posterior thigh (M) in line with the horizontal incision bifurcating the anterior margin of the anus (J).
8. Remove the skin from the labium majus from medial to lateral.
9. Detach each skin flap along the medial surface of the thigh and place it in the tissue container.
10. If the cadaver has a large amount of fat in the superficial fascia of the medial thighs, remove a portion of the superficial fascia corresponding to the areas of removed skin.

## Female Superficial Perineal Pouch and Clitoris

ATLAS 5.46, 5.58A, 5.59A, 5.61; VIDEO 5.8.4

1. Refer to FIGURE 5.33.
2. In the female, three pairs of muscles (left and right) overlay the erectile tissue of the clitoris and contribute to the **contents of the superficial perineal pouch** with the accompanying **arteries, veins, and nerves** that supply the structures.
3. Identify the three muscles of the superficial pouch: the **ischiocavernosus muscle**, the **bulbospongiosus muscle**, and the **superficial transverse perineal muscle**.
4. Identify the **posterior labial nerve and vessels** and observe that they are terminal branches of the **superficial branch of the perineal artery and nerve** and supply the posterior part of the labium majus. *Note that the superficial branch of the perineal artery and nerve enter the urogenital triangle by passing lateral to the external anal sphincter muscle.*
5. It is not necessary to identify the **membranous layer of the superficial perineal fascia (Colles' fascia)** to complete the dissection. Rather, review the attachments of the Colles' fascia by palpating the **ischiopubic ramus** and **ischial tuberosity** as well as the posterior edge of the **perineal membrane**. *Note that the Colles' fascia forms the superficial boundary of the* ***superficial perineal pouch*** *(space).*
6. Use a probe to dissect through the superficial perineal fascia about 2 cm lateral to the labium minus. Remove the mass of fat contained in the labium majus and place it in the tissue container.

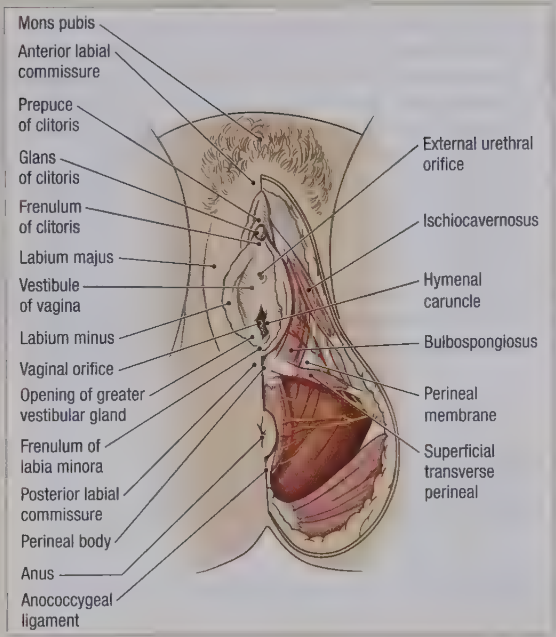

Mons pubis
Anterior labial commissure
Prepuce of clitoris
Glans of clitoris
Frenulum of clitoris
Labium majus
Vestibule of vagina
Labium minus
Vaginal orifice
Opening of greater vestibular gland
Frenulum of labia minora
Posterior labial commissure
Perineal body
Anus
Anococcygeal ligament
External urethral orifice
Ischiocavernosus
Hymenal caruncle
Bulbospongiosus
Perineal membrane
Superficial transverse perineal

FIGURE 5.33 ● Contents of the female superficial perineal pouch. Inferior view.

7. Use blunt dissection to find the **bulbospongiosus muscle** deep to the labium minus overlying the bulb of the vestibule.
8. Observe that the bulbospongiosus muscle covers the surface of the **bulb of the vestibule** and lies anterior to the dense fascia of the **perineal body**. *Note that the bulbospongiosus muscle in the female does not join the bulbospongiosus muscle of the opposite side across the midline as it does in the male.*
9. Review the attachments and actions of the **bulbospongiosus muscle** (see **TABLE 5.2**).
10. Lateral to the bulbospongiosus muscle, use a probe to clean the surface of the **ischiocavernosus muscle** overlying the superficial surface of the **crus of the clitoris**.
11. Using blunt dissection, attempt to find the **superficial transverse perineal muscle** at the posterior border of the urogenital triangle.
12. Observe that the superficial transverse perineal muscle helps to support the **perineal body**, a fibromuscular mass located anterior to the anal canal and posterior to the perineal membrane. *Note that the superficial transverse perineal muscle may be delicate and difficult to find. Limit the time you spend looking for it.*
13. Refer to FIGURE 5.34.

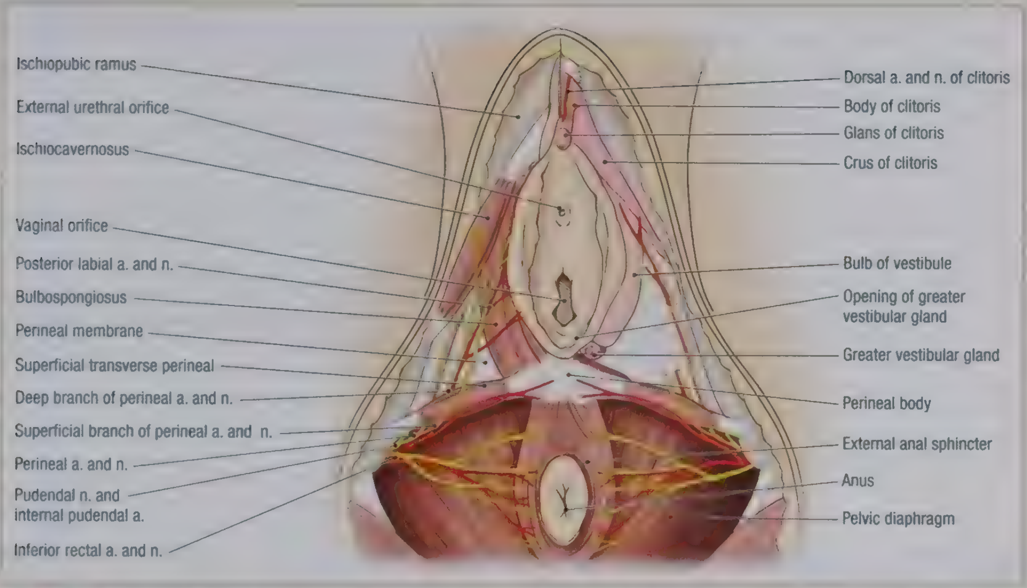

Ischiopubic ramus
External urethral orifice
Ischiocavernosus
Vaginal orifice
Posterior labial a. and n.
Bulbospongiosus
Perineal membrane
Superficial transverse perineal
Deep branch of perineal a. and n.
Superficial branch of perineal a. and n.
Perineal a. and n.
Pudendal n. and internal pudendal a.
Inferior rectal a. and n.
Dorsal a. and n. of clitoris
Body of clitoris
Glans of clitoris
Crus of clitoris
Bulb of vestibule
Opening of greater vestibular gland
Greater vestibular gland
Perineal body
External anal sphincter
Anus
Pelvic diaphragm

FIGURE 5.34 ■ Contents of the female superficial perineal pouch in superficial (*right*) and deep (*left*) dissections. Inferior view.

14. Use blunt dissection to clean between the three muscles of the superficial perineal pouch until a small triangular opening is created.
15. Within the triangular opening, identify the **perineal membrane**. The perineal membrane is the deep boundary of the superficial perineal pouch.
16. On the left side of the cadaver, use blunt dissection to remove the bulbospongiosus muscle and identify the **bulb of the vestibule**.
17. Observe that the bulb of the vestibule is an elongated mass of erectile tissue that lies lateral to the vaginal orifice. The **greater vestibular gland** is found in the superficial perineal pouch immediately posterior to the bulb of the vestibule. *Note that in the cadaver, the greater vestibular gland is difficult to find.*
18. Anteriorly, the bulbs of the two sides are joined at the **commissure of the bulbs,** which is continuous with the **glans of the clitoris**. Do not attempt to find the commissure of the bulbs.
19. On the left side of the cadaver, use blunt dissection to remove the ischiocavernosus muscle from the **crus of the clitoris**. Observe that the crus of the clitoris attaches to the ischiopubic ramus and is continuous with the corpus cavernosum clitoris.
20. Study the erectile bodies of the clitoris and observe that the two corpora cavernosa form the body of the clitoris and that the glans clitoris caps the two corpora cavernosa.

## Female Deep Perineal Pouch

ATLAS 5.47D, 5.62; VIDEO 5.8.5

***Dissection Note:*** The deep perineal pouch lies superior (deep) to the perineal membrane and will be minimally dissected as few of the structures are easily identifiable.

1. Refer to FIGURE 5.35 to study the **contents of the deep perineal pouch in the female**.
2. Identify the **urethra** in the midsagittal plane and observe that it pierces the **perineal membrane**.

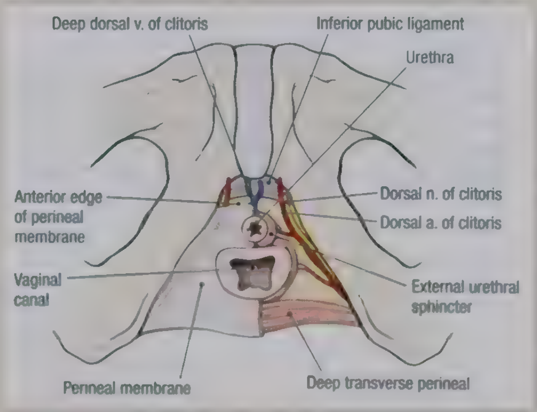

Deep dorsal v. of clitoris
Inferior pubic ligament
Urethra
Anterior edge of perineal membrane
Dorsal n. of clitoris
Dorsal a. of clitoris
Vaginal canal
External urethral sphincter
Perineal membrane
Deep transverse perineal

FIGURE 5.35 ■ Contents of the female deep perineal pouch. Inferior view.

The female urethra extends from the internal urethral orifice in the urinary bladder to the external urethral orifice in the vestibule of the vagina (about 4 cm).

3. Observe that the **external urethral sphincter (sphincter urethrae) muscle** surrounds the membranous urethra. The external urethral sphincter muscle is a voluntary muscle that when contracted compresses the membranous urethra and stops the flow of urine.
4. Posterior to the opening of the **urethra**, identify the **vaginal** opening.
5. Identify the **deep transverse perineal muscle** (paired) along the posterior margin of the deep perineal pouch. Collectively, the muscles within the deep perineal pouch plus the perineal membrane are known as the **urogenital diaphragm**. *Note that its fiber direction and function are identical to those of the superficial transverse perineal muscle, which is located in the superficial perineal pouch.*
6. Review the attachments and actions of the **external urethral sphincter** and the **deep transverse perineal muscle** (see **TABLE 5.2**).
7. Coursing anterior along the lateral margin of the deep perineal pouch, identify the **branches of the internal pudendal artery and vein** (most notably, the dorsal artery of the clitoris) and the **branches of the pudendal nerve** (most notably, the dorsal nerve of the clitoris). These structures supply the external urethral sphincter muscle, the deep transverse perineal muscle, and the clitoris.

**CLINICAL CORRELATION**

### Obstetric Considerations

ATLAS 5.30E, 5.30G, 5.59

To alleviate the pain of childbirth, multiple nerve blocks may be performed. A spinal block at the L3/L4 vertebral level will introduce anesthesia from the waist down, including the perineum, pelvic floor, and birth canal. Alternatively, a caudal epidural block will anesthetize most of the perineal region, the entire birth canal, and pelvic floor without affecting the lower limbs. A pudendal nerve block is the most localized and only blocks the portion of the perineum innervated by the pudendal nerve in the perineum, thus sparing the upper portion of the birth canal and uterus so the mother can still feel uterine contractions.

As the head of the baby passes through the vagina during childbirth, the anus and the levator ani muscles are forced posteriorly toward the sacrum and coccyx. The urethra is forced anteriorly toward the pubic symphysis. Perineal lacerations during childbirth are common, and it may be necessary to surgically widen the vaginal orifice (episiotomy). If the perineal body is lacerated, it must be repaired to prevent weakness of the pelvic floor; otherwise, it could result in prolapse of the urinary bladder, uterus, or rectum.

## Dissection Follow-up

1. Review the muscles of the female superficial perineal pouch in **TABLE 5.2**.
2. Replace the muscles of the urogenital triangle in their correct anatomical positions.
3. Review the contents of the female superficial perineal pouch. Visit a dissection table with a male cadaver and view the contents of the superficial perineal pouch.
4. Review the course of the internal pudendal artery from its origin in the pelvis.
5. Review the course and branches of the pudendal nerve.
6. Review the path of the female urethra and note its course from the urinary bladder to the perineum as compared to the male urethra.
7. Return the reflected portions of tissue back to anatomical position.

TABLE 5.2 **Female Superficial and Deep Perineal Pouches**

SUPERFICIAL GROUP OF MUSCLES

| *Muscle* | *Anterior Attachments* | *Posterior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Bulbospongiosus | Corpus cavernosum clitoris | Perineal body | Compresses the bulb of the clitoris | Deep branch of the perineal n. (branch of pudendal n.) |
| Ischiocavernosus | Crus of the clitoris | Ischial tuberosity and ischiopubic ramus | Forces blood from the crus of the clitoris into the distal part of the corpus cavernosum clitoris | |
| Superficial transverse perineal | Perineal body (medial attachment) | Ischial tuberosity (lateral attachment) | Provides support to the perineal body | Perineal n. (branch of pudendal n.) |

DEEP GROUP OF MUSCLES

| *Muscle* | *Anterior Attachments* | *Posterior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Deep transverse perineal | Perineal body (medial attachment) | Ischial tuberosity (lateral attachment) | Provides support to the perineal body | Perineal n. (branch of pudendal n.) |
| External urethral sphincter | Attaches to itself around the urethra | | Compresses the membranous urethra and stops the flow of urine | Deep branch of the perineal n. (branch of pudendal n.) |

Abbreviation: n., nerve.

# FEMALE PELVIC CAVITY

## Dissection Overview

The female pelvic cavity contains the urinary bladder anteriorly, the female internal genitalia, and the rectum posteriorly. The term *adnexa* refers to the ovaries, uterine tubes, and ligaments of the uterus. Removal of the uterus (hysterectomy), with or without the ovaries, is a common surgical procedure. If the uterus has been surgically removed from your cadaver, examine it in other cadavers.

The order of dissection will be as follows: The peritoneum will be studied in the female pelvic cavity. The pelvis will be sectioned in the midline, and the cut surface of the sectioned pelvis will be studied. The uterus and vagina will be studied. The uterine tube will be traced from the uterus to the ovary. The ovary will be studied.

## Dissection Instructions

### Female Pelvic Peritoneum

ATLAS 5.14, 5.30A; VIDEO 5.9.1

1. Refer to FIGURE 5.36.
2. Identify the peritoneum on the posterior aspect of the anterior abdominal wall superior to the pubis (**1**).
3. Observe that the peritoneum reflects from the anterior abdominal wall inferiorly across the apex of the urinary bladder (**2**).
4. Observe that the peritoneum courses along the superior surface of the urinary bladder (**3**) but not its posterior surface.
5. Identify the **paravesical fossa** (paired), the shallow depressions in the peritoneal cavity on the lateral sides of the urinary bladder.
6. Follow the lining of the peritoneum posteriorly and observe that it passes from the superior surface of the urinary bladder to the uterus to form the **vesicouterine pouch** (**4**).

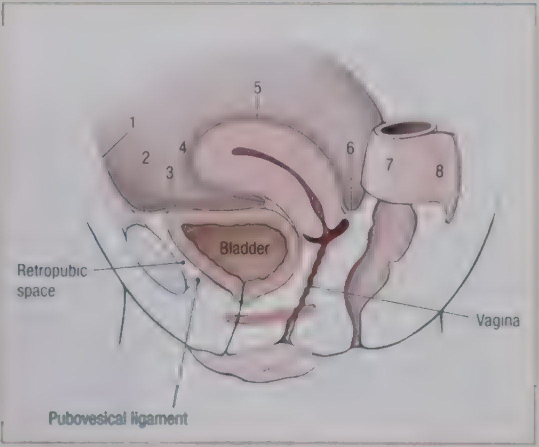


FIGURE 5.36 ■ Female pelvic peritoneum. Midsagittal view.

7. Observe that the peritoneum in the female additionally covers the fundus and body of the uterus (**5**) and contacts the wall of the posterior part of the vaginal fornix.
8. Observe that the peritoneum covers a depression between the uterus and the rectum, the **rectouterine pouch** (the pouch of Douglas) (**6**), the lowest point in the female abdominopelvic cavity.

### CLINICAL CORRELATION

**The Uterus**

ATLAS 5.30, 5.31, 5.36

The adult uterus is typically anteverted (tilted anteriorly) and anteflexed (bent anteriorly) over the surface of the urinary bladder. The orientation and position of the uterus allows for expansion into the abdominal cavity during pregnancy, though simultaneously it compresses the urinary bladder preventing filling thus increasing the need and frequency of urination.

The uterus grows throughout childhood and adolescence and will gain a thicker muscular wall following single or multiple pregnancies. Following parturition, the uterus will regress to a smaller size, and it will substantially decrease in volume and thickness following menopause. Heavy menstrual flows caused by fibroids, pelvic pain due to endometrioses, or a prolapsed uterus may warrant a hysterectomy (surgical removal of the uterus).

9. Follow the peritoneum superiorly along the posterior aspect of the pelvic cavity on the anterior surface of the rectum (**7**) and observe that it forms the sigmoid mesocolon at the level of the third sacral vertebra.
10. Identify the **pararectal fossa** (paired), the shallow depressions in the peritoneal cavity on the lateral sides of the rectum (**8**).

## Broad Ligament

ATLAS 5.30D, 5.33; VIDEO 5.9.2

1. Refer to FIGURE 5.37.
2. Identify the **broad ligament of the uterus**. The broad ligament of the uterus is formed by two layers of peritoneum, which extend bilaterally from the lateral side of the uterus to the lateral pelvic wall. *Note that the connective tissue enclosed between the two layers of the broad ligament is called* ***parametrium****.*
3. Observe that the **uterine tube** is contained within the superior margin of the broad ligament. The portion of the broad ligament surrounding the uterine tube is called the **mesosalpinx**.
4. The portion of the broad ligament that suspends the ovaries is the **mesovarium**. The portion of the broad ligament that is adjacent to the body of the uterus is the **mesometrium**.
5. Identify the **round ligament of the uterus** (paired), visible through the anterior layer of the broad ligament.
6. Observe that the round ligament of the uterus passes over the pelvic brim and exits the abdominal cavity by passing through the deep inguinal ring lateral to the inferior epigastric vessels. The round ligament of the uterus passes through the inguinal canal and ends in the labium majus.
7. Identify the **ovarian ligament** (paired), a fibrous cord within the broad ligament that connects the ovary to the uterus.

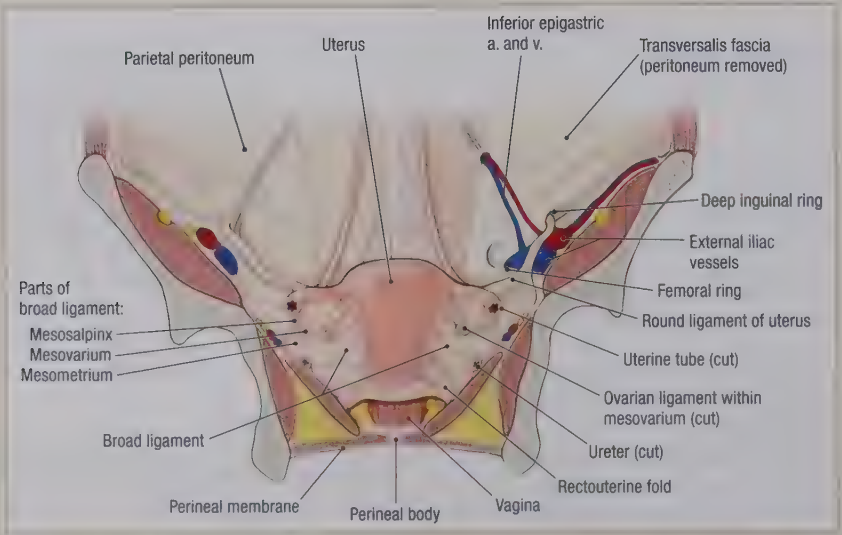

Parietal peritoneum
Uterus
Inferior epigastric a. and v.
Transversalis fascia (peritoneum removed)
Deep inguinal ring
External iliac vessels
Femoral ring
Round ligament of uterus
Parts of broad ligament:
Mesosalpinx
Mesovarium
Mesometrium
Uterine tube (cut)
Ovarian ligament within mesovarium (cut)
Broad ligament
Ureter (cut)
Rectouterine fold
Perineal membrane
Perineal body
Vagina

FIGURE 5.37 ■ Uterus, broad ligament, and female internal genitalia with removed peritoneum (*right*). Posterior view.

8. Identify the **suspensory ligament of the ovary** (paired), a peritoneal fold that covers the ovarian vessels.
9. Observe that the suspensory ligament of the ovary extends into the greater pelvis from the posterior abdominal wall.
10. Observe that the endopelvic fascia includes distinct condensations of tissue: the **uterosacral (sacrogenital) ligament** (paired), which extends from the cervix to the sacrum underlying the **uterosacral fold**; the **transverse cervical ligament (cardinal ligament)** (paired), which extends from the cervix to the lateral wall of the pelvis; and the **pubocervical (pubovesical)** (paired) ligament, which extends from the pubis to the cervix. *Note that the* ***endopelvic fascia*** *(extraperitoneal fascia) contains condensations of connective tissue that passively support the uterus.*

## Section of the Female Pelvis

ATLAS 5.30, 5.48; VIDEO 5.9.3

***Dissection Note:*** The pelvis will be divided in the midline up to vertebral level L3 with a saw. Subsequently, the left side of the body will be transected at vertebral level L3, enabling removal of the left lower limb and left hemi pelvis. The right lower limb and right side of the pelvis will remain attached to the trunk.

1. Refer to FIGURE 5.38A.
2. In the female pelvic cavity, make a midline cut beginning posterior to the pubic symphysis through the superior surface of the urinary bladder (**Cut 1**). Spread open the bladder and sponge the interior if necessary.
3. Position the uterus in the midline and use a scalpel to divide the uterus in *its* median plane, which may or may not align with the midline of the pelvis (**Cut 2**). *Note that female cadavers may or may not have an intact uterus or other internal pelvic organs following hysterectomy procedures.*
4. Extend the cut through the midline of the cervix inferiorly and into the fornix of the vaginal canal.
5. Extend the midline cut in the posterior direction cutting through the anterior and posterior walls of the rectum and the distal part of the sigmoid colon (**Cut 3**).
6. Clean the internal aspect of the rectum and anal canal. *Use caution when cleaning and moving fecal matter. Refer to your instructor for proper safety techniques.*
7. Use a scalpel to cut the left common iliac vein, left common iliac artery, left ovarian vessels, and left ureter about 1 cm distal to their respective points of origin (**Cuts 4**).
8. Cut through the left lumbar arteries at vertebral levels L4 and L5 and reflect the abdominal aorta to the right side of the abdominal cavity.
9. Use a scalpel to make an incision through the muscles of the lateral abdominal wall about 2 cm superior to the iliac crest and cut medially to the vertebral column (**Cut 5**).
10. Cut through the nerves of the left lumbar plexus at the point they cross the horizontal incision and use the scalpel to cut through any remaining fibers of the left psoas major and quadratus lumborum muscles at vertebral level L3.
11. Refer to FIGURE 5.38B.

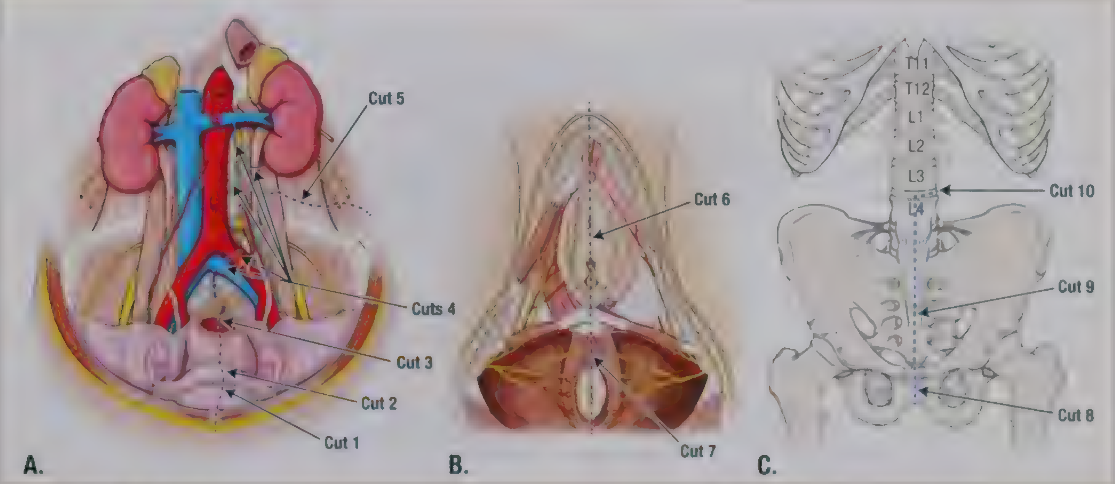


FIGURE 5.38 A. Soft tissue cuts for female pelvic bisection. Anterior view. B. Perineal cuts for female pelvic bisection. Inferior view. C. Skeletal cuts for female pelvic bisection and left lower limb and pelvis detachment. Anterior view.

12. Identify the internal urethral orifice in the bladder and insert a probe into it. Using the probe as a guide, cut through the inferior part of the bladder, dividing the urethra.
13. In the perineum, insert the tip of a probe into the external urethral orifice. Use the probe as a guide to make a midline cut through the clitoris, dividing it into right and left sides. Extend this cut posteriorly, dividing the urethra and vagina into right and left sides (**Cut 6**).
14. In the midline, extend the cut to the tip of the coccyx cutting through the perineal membrane, perineal body, and anal canal (**Cut 7**).
15. Refer to FIGURE 5.38C.
16. With the cadaver in the supine position, use a saw to cut through the pubic symphysis in the midline from anterior to posterior, stopping at the inferior border of the pubic symphysis (**Cut 8**).
17. Turn the cadaver 90° to the right, so it is lying on its right side. Prop the cadaver or have your lab partners hold the body so it does not fall or rotate.
18. Have your lab partners abduct the left lower limb to facilitate sectioning of the sacrum.
19. Cut through the sacrum from posterior to anterior (**Cut 9**). Make an effort to not allow the saw to contact the soft tissue structures that were cut with the scalpel. Retract the soft tissue structures out of the path of the blade if necessary.
20. Forcibly spread apart the lower limbs to expand the opening division of the sacrum and extend the midline cut as far superiorly as the body of the third lumbar vertebra.
21. Adduct the left lower limb and use the saw to cut horizontally through the left half of the intervertebral disc between L3 and L4 (**Cut 10**), sparing the inferior aspect of the abdominal aorta.
22. Once the horizontal and vertical cuts are connected, return the cadaver to the supine position.
23. Cut any remaining pieces of tissue preventing the left lower limb from being removed and pull the left lower limb away from the rest of the cadaver.
24. Clean the rectum and anal canal on both sides of the bisected pelvic specimen.

## Female Internal Genitalia

ATLAS 5.14, 5.30, 5.33; VIDEO 5.9.4

1. Refer to FIGURE 5.39.
2. Trace the sectioned urethra anteroinferiorly from the urinary bladder to the **external urethral orifice** and attempt to identify the **external urethral sphincter muscle**. *Note that the external urethral sphincter muscle may be difficult to see.*
3. In the sectioned specimen, identify the **vagina**. Observe that the anterior vaginal wall is shorter than the posterior vaginal wall.
4. Within the vaginal canal, identify the **vaginal fornix** surrounding the inferior most aspect of the uterus, the **cervix**. Observe that the vaginal fornix has an **anterior part**, a **posterior part**, and a **lateral part** (paired: right and left).

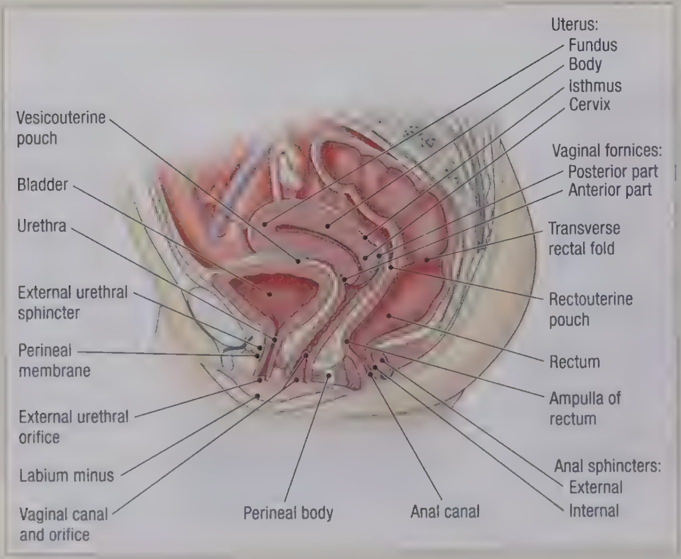

Uterus:
Fundus
Body
Isthmus
Cervix
Vesicouterine pouch
Bladder
Urethra
Vaginal fornices:
Posterior part
Anterior part
Transverse rectal fold
External urethral sphincter
Rectouterine pouch
Perineal membrane
Rectum
Ampulla of rectum
External urethral orifice
Anal sphincters:
External
Internal
Labium minus
Vaginal canal and orifice
Perineal body
Anal canal

FIGURE 5.39 ■ Midline section of the female pelvis. Midsagittal view.

5. Observe that the posterior wall of the vagina (near the posterior part of the vaginal fornix) is in contact with the peritoneum that lines the rectouterine pouch.
6. Study the **uterus** and observe that it is tilted approximately 90° anterior to the axis of the vagina (anteverted). *Note that the position of the uterus changes as the bladder fills and during pregnancy.*
7. Identify the **fundus of the uterus**, the rounded portion that lies superior to the attachments of the uterine tubes.
8. Inferior to the fundus, identify the **body of the uterus**. Observe that the **vesical surface** of the body of the uterus faces the vesicouterine pouch and the **intestinal surface** faces the rectouterine pouch. *Note that the broad ligament is attached to the lateral surface of the body of the uterus.*
9. Identify the **isthmus of the uterus**, the narrowed portion of the body superior to the **cervix**. The **cervix** is the thick-walled portion of the uterus that protrudes into the vaginal canal.
10. Refer to FIGURE 5.40.
11. Identify the **uterine cavity**. Observe that in a sagittal section, it is a slit, whereas in a coronal section, it is triangular.
12. Observe that the uterine wall contains three distinct layers. The bulk of the wall of the uterus is composed of the thick muscular wall called **myometrium**. The **endometrium** is the innermost aspect of the uterine wall formed by uterine mucosa, and the **perimetrium** covers the external surface of the uterus. *Note that the tissues within the broad ligament are called parametrium.*
13. Identify the **uterine (fallopian) tube**. Use your fingers to follow the uterine tube as it passes laterally within the mesosalpinx beginning at the **isthmus**, the narrow medial one-third of the uterine tube.
14. Continue to palpate laterally along the length of the uterine tube and identify the **ampulla**, the widest and longest part of the uterine tube. The ampulla transitions to the **infundibulum**, the funnel-like end of the uterine tube.
15. Identify the **fimbriae**, the fingerlike processes that surround the distal margin of the infundibulum.
16. Identify the **ovary**. Observe that the ovary is ovoid, with a **tubal (distal) extremity** where the ovarian vessels enter the ovary, and a **uterine (proximal) extremity** attached to the ligament of the ovary.
17. Observe that the ovary sits in the **ovarian fossa**, a shallow depression in the lateral pelvic wall bounded by the ureter, external iliac vein, and uterine tube.
18. Review the abdominal origin and course of the ovarian vessels and note that they pass through the **suspensory ligament of the ovary**.

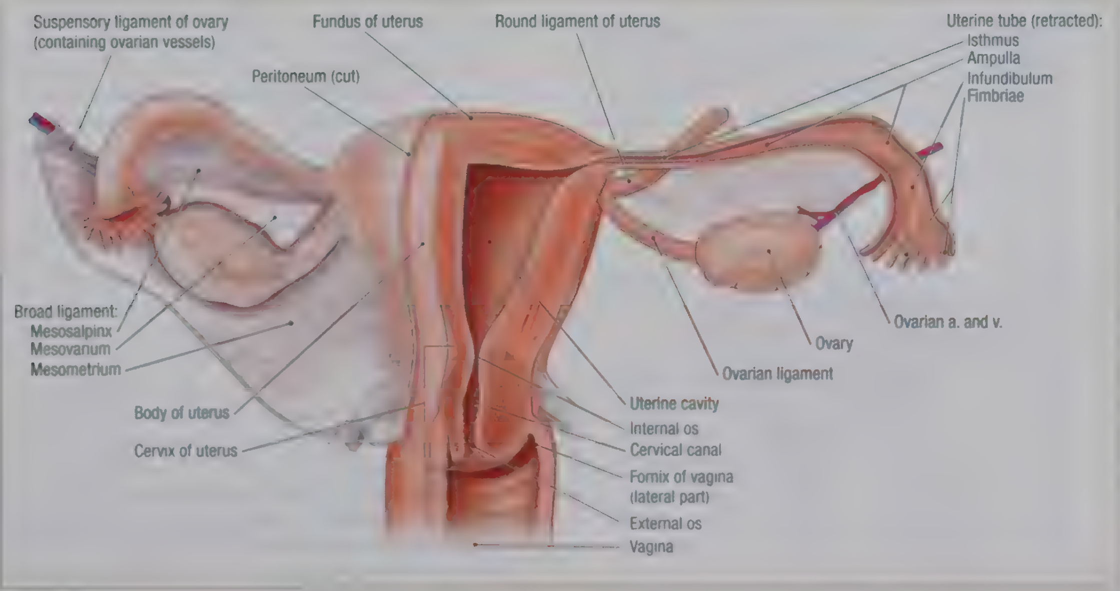

Suspensory ligament of ovary (containing ovarian vessels)
Fundus of uterus
Round ligament of uterus
Uterine tube (retracted):
Isthmus
Ampulla
Infundibulum
Fimbriae
Peritoneum (cut)
Broad ligament:
Mesosalpinx
Mesovarium
Mesometrium
Body of uterus
Cervix of uterus
Ovarian a. and v.
Ovary
Ovarian ligament
Uterine cavity
Internal os
Cervical canal
Fornix of vagina (lateral part)
External os
Vagina

FIGURE 5.40 ● Uterus, uterine tubes, ovaries, and broad ligament. Posterior view.

## Dissection Follow-up

1. Review the position of the female pelvic viscera within the pelvic cavity.
2. Visit a dissection table with a male cadaver and observe the position of the male pelvic viscera.
3. Review the peritoneum in the female pelvic cavity. Visit a dissection table with a male cadaver and compare differences in the female and male peritoneum.
4. Trace the round ligament of the uterus from the superficial inguinal ring to the uterus.
5. Compare the pelvic course of the ductus deferens with the pelvic course of the round ligament of the uterus.
6. Review the parts of the broad ligament and review the function of the endopelvic fascia in passive support of the uterus.
7. Return the reflected tissue back to anatomical position.

# FEMALE URINARY BLADDER, RECTUM, AND ANAL CANAL

## Dissection Overview

The urinary bladder is a reservoir for urine. When empty, it is located within the pelvic cavity. When filled, it extends into the abdominal cavity. The urinary bladder is a retroperitoneal organ that is surrounded by endopelvic fascia. Between the pubic symphysis and the urinary bladder, there is a potential space called the retropubic space (prevesical space). The retropubic space is filled with fat and loose connective tissue that accommodates the expansion of the urinary bladder. The pubovesical ligament is a condensation of fascia that ties the neck of the urinary bladder to the pubis across the retropubic space. The pubovesical ligament defines the inferior limit of the retropubic space. The lower two-thirds of the rectum is surrounded by endopelvic fascia. The upper one-third of the rectum is partially covered by peritoneum.

The order of dissection will be as follows: The parts of the urinary bladder will be studied. The interior of the urinary bladder will be studied. The interior of the rectum and anal canal will be studied.

## Dissection Instructions

### Female Urinary Bladder

ATLAS 5.30, 5.34; VIDEO 5.10.1

1. Refer to FIGURE 5.41.
2. Begin identification of the **parts of the urinary bladder** with the **apex**, the pointed part directed toward the anterior abdominal wall and identified by the attachment of the urachus.

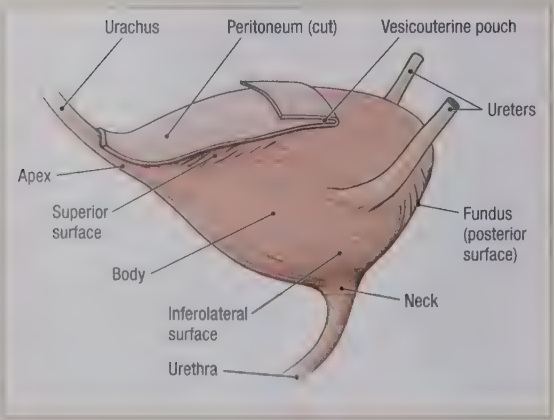


FIGURE 5.41 ● Parts of the female urinary bladder. Lateral view.

3. Observe that the **body of the urinary bladder** is located between the apex and the **fundus**. The fundus of the bladder is the inferior part of the posterior wall, also called the **base of the urinary bladder**.
4. Observe the proximity of the fundus of the bladder to the vagina and uterus. *Note that in the male, the fundus is related to the ductus deferens, seminal vesicles, and rectum.*
5. Identify the **neck of the urinary bladder**, the portion where the urethra exits the urinary bladder and the wall thickens to form the **internal urethral sphincter**. *Note that the internal urethral sphincter is positioned at the junction of the urinary bladder and the urethra and is an involuntary muscle controlled by the autonomic nervous system.*
6. Observe that the **superior surface of the urinary bladder** is covered by peritoneum, whereas the **posterior surface** lies immediately adjacent to the anterior cervix and anterior wall of the vagina, separated from them by a thin layer of endopelvic fascia.
7. Verify that the **inferolateral** (paired) surface of the urinary bladder is covered by endopelvic fascia and lies below the reflection point of the peritoneum.
8. Examine the **wall of the urinary bladder** noting its thickness and observe that it consists of bundles of smooth muscle called **detrusor muscle**. *Note that the mucous membrane lining the majority of the inner surface of the urinary bladder lies in folds when the bladder is empty but will flatten out to accommodate expansion.*

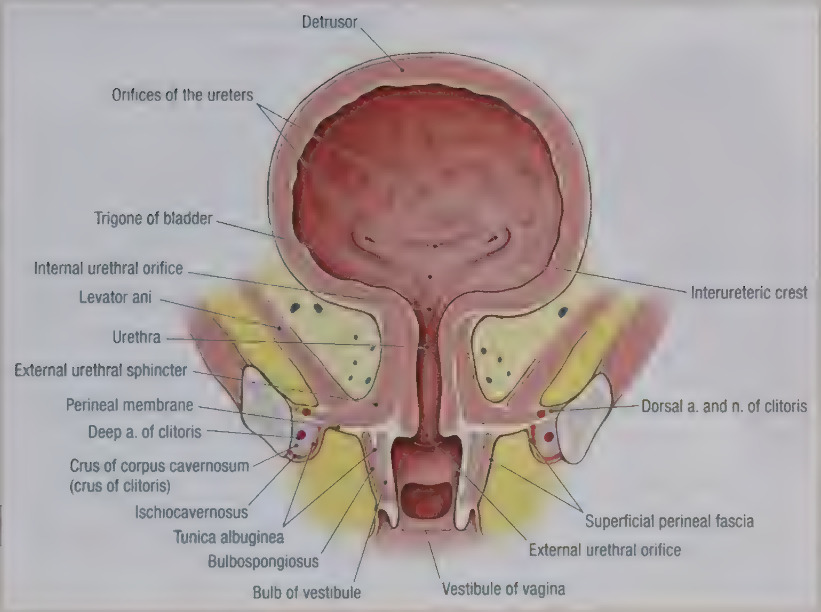

Detrusor
Orifices of the ureters
Trigone of bladder
Internal urethral orifice
Levator ani
Urethra
External urethral sphincter
Perineal membrane
Deep a. of clitoris
Crus of corpus cavernosum (crus of clitoris)
Ischiocavernosus
Tunica albuginea
Bulbospongiosus
Bulb of vestibule
Vestibule of vagina
External urethral orifice
Superficial perineal fascia
Dorsal a. and n. of clitoris
Interureteric crest

FIGURE 5.42 ● Coronal section of the female urinary bladder and urethra. Anterior view.

9. Refer to FIGURE 5.42.
10. Study the inner surface of the fundus and identify the **trigone of the urinary bladder (urinary trigone)**. The trigone of the bladder is a smooth, triangular region of mucous membrane defined by lines between the **internal urethral orifice** and the two **ureteric orifices**. Identify the **interureteric crest**, a visible ridge extending between the orifices of the ureters.
11. On the inner surface of the bisected fundus of the cadaver, identify one-half of the **trigone of the urinary bladder**. Observe that the internal urethral orifice is located at the most inferior point in the urinary bladder.
12. Insert the tip of a probe into the orifice of the ureter and observe that the ureter passes through the muscular wall of the urinary bladder in an oblique direction. When the urinary bladder is full (distended), the pressure of the accumulated urine flattens the part of the ureter within the wall of the bladder and thus prevents reflux of urine into the ureter.
13. Find the ureter where it crosses the external iliac artery, or the bifurcation of the common iliac artery, and use blunt dissection to follow the ureter to the fundus of the urinary bladder. Observe that the ureter crosses inferior to the **uterine artery** and superior to the **vaginal artery**.

## Female Rectum and Anal Canal

ATLAS 5.16C, 5.16D, 5.17, 5.30A; VIDEO 5.10.2

1. Refer back to FIGURE 5.39 and FIGURE 5.43.
2. Identify the **rectum** at its point of origin at the level of the third sacral vertebra. On the sectioned pelvis, observe that the rectum follows the curvature of the sacrum.
3. Identify the **ampulla of the rectum**, the dilated portion of the rectum proximal to the point where the rectum bends approximately 80° posteriorly **(anorectal flexure)**. Observe that the ampulla of the rectum is continuous with the anal canal.
4. Examine the inner surface of the rectum and observe that the mucous membrane is smooth except for the presence of **transverse rectal folds**. There is usually one transverse rectal fold on the right side of the rectum and two on the left side. *Note that the transverse rectal folds may be difficult to identify in some cadavers.*
5. Observe that the **anal canal** is only 2.5 to 3.5 cm in length and passes out of the pelvic cavity and into the anal triangle of the perineum.
6. Examine the inner surface of the anal canal and identify the **anal columns**, 5 to 10 longitudinal ridges of mucosa in the proximal part of the anal canal. The anal columns contain branches of the **superior rectal artery** and **vein**. *Note that the mucosal features of the anal canal may be difficult to identify in older individuals.*

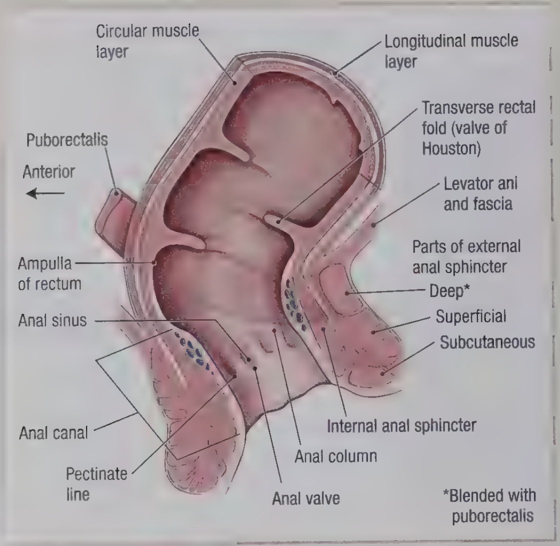

Circular muscle layer
Longitudinal muscle layer
Transverse rectal fold (valve of Houston)
Puborectalis
Anterior
Levator ani and fascia
Parts of external anal sphincter
Ampulla of rectum
Deep*
Anal sinus
Superficial
Subcutaneous
Internal anal sphincter
Anal canal
Anal column
Pectinate line
Anal valve
*Blended with puborectalis

FIGURE 5.43 Distal rectum, anal sphincters, and anal canal. Midsagittal view.

CLINICAL CORRELATION

### Hemorrhoids

ATLAS 5.18D

Hemorrhoids, or piles, are dilations of the veins around the anal canal and commonly occur in adults with or without underlying pathology. Hemorrhoids can result from conditions that increase intra-abdominal pressure (such as obesity and pregnancy), and portal hypertension, which may be a consequence of cirrhosis of the liver. Increase in blood pressure and engorgement of the veins contained in the anal columns result in internal hemorrhoids. Internal hemorrhoids are covered by mucous membrane and are relatively insensitive to painful stimuli because the mucous membrane is innervated by autonomic nerves. External hemorrhoids are enlargements of the tributaries of the inferior rectal veins, are covered by skin, and are very sensitive to painful stimuli because they are innervated by somatic nerves (inferior rectal nerves).

7. Identify the semilunar folds of mucosa forming the **anal valves**, which unite the distal ends of the anal columns. Between the anal valve and the wall of the anal canal is a small pocket called an **anal sinus**.
8. Identify the **pectinate line**, the irregular line formed by the contour of the collective anal valves.
9. Identify the **external anal sphincter muscle** in the sectioned specimen surrounding the anal canal. *Note that the external anal sphincter is composed of skeletal muscle and is under voluntary control.*
10. Identify the **internal anal sphincter muscle** in the sectioned specimen surrounding the anal canal. *Note that the internal anal sphincter is composed of smooth muscle and is under involuntary control.*
11. Observe that the longitudinal muscle of the anal canal separates the two sphincter muscles. If you have difficulty identifying the anal sphincters, use a scalpel to cut another section through the wall of the anal canal to improve the clarity of the dissection.

## Dissection Follow-up

1. Use the dissected specimen to review the features of the urinary bladder, rectum, and anal canal.
2. Review the relationships of the uterus, vagina, and ureters to the rectum and fundus of the urinary bladder.
3. Visit a dissection table with a male cadaver and review the relationships of the seminal vesicles, ampulla of the ductus deferens, and ureters to the rectum and fundus of the urinary bladder.
4. Review the kidney, the abdominal course of the ureter, the pelvic course of the ureter, and the function of the urinary bladder as a storage organ.
5. Review the female urethra. Visit a table with a male cadaver and review the parts of the male urethra.
6. Review all parts of the large intestine and recall its function in absorption of water and in compaction and elimination of fecal material.
7. Recall that the external anal sphincter muscle is composed of skeletal muscle and is under voluntary control, whereas the internal anal sphincter muscle is composed of smooth muscle and is involuntary.

# FEMALE INTERNAL ILIAC ARTERY AND SACRAL PLEXUS

## Dissection Overview

Anterior to the sacroiliac articulation, the common iliac artery divides to form the external and internal iliac arteries. The external iliac artery distributes to the lower limb, and the internal iliac artery distributes to the pelvis. The internal iliac artery commonly divides into an anterior division and a posterior division. Branches arising from the anterior division are mainly visceral and supply the urinary bladder, internal genitalia, external genitalia, rectum, and gluteal region. Branches arising from the posterior division are parietal and supply the pelvic walls and gluteal region.

The somatic plexuses of the pelvic cavity, the sacral plexus and the coccygeal plexus, are located between the pelvic viscera and the lateral pelvic wall embedded in the endopelvic fascia. These somatic nerve plexuses are formed by contributions from anterior rami of spinal nerves L4–Co1. The primary visceral nerve plexus of the pelvic cavity is the inferior hypogastric plexus (pelvic plexus), formed by contributions from the hypogastric nerves, sacral splanchnic nerves (sympathetic), and pelvic splanchnic nerves (parasympathetic).

The order of dissection will be as follows: The branches of the posterior division of the internal iliac artery will be identified. The branches of the anterior division of the internal iliac artery will be identified. The nerves of the sacral plexus will be dissected. Finally, the pelvic portion of the sympathetic trunk will be dissected.

## Dissection Instructions

### Female Pelvic Blood Vessels

ATLAS 5.38; VIDEO 5.11.1

***Dissection Note:*** The dissection of the pelvic vasculature may be performed on both the right and left sides of the hemisected pelvis; however, it is recommended to focus the dissection on just the right side because a deeper dissection will be performed on the left side with the detached lower limb.

1. Refer to FIGURE 5.44.
2. Identify the **internal iliac vein** and observe that its tributaries largely parallel the nearby arteries but are plexiform in nature. To clear the dissection field, remove all tributaries to the internal iliac vein as each correlating artery is identified and cleaned.
3. Identify the locations of the **vesical venous plexus**, **uterine venous plexus**, **vaginal venous plexus**, and **rectal venous plexus**. *Note that all of these plexuses drain into the internal iliac vein.*
4. Identify and clean the **common iliac artery** and follow it distally until it bifurcates into the **external iliac artery** and **internal iliac artery**.
5. Use blunt dissection to follow the internal iliac artery into the pelvis and observe that it gives numerous smaller vessels from two major divisions, anterior and posterior.
6. Begin identification of the branches of the posterior division of the internal iliac artery by finding the most posterior and superior branch, the **iliolumbar artery**.
7. Observe that the **iliolumbar artery** branches posteriorly from the posterior division and then ascends lateral to the **sacral promontory**, lumbar vertebrae, lumbosacral trunk, and the obturator nerve.

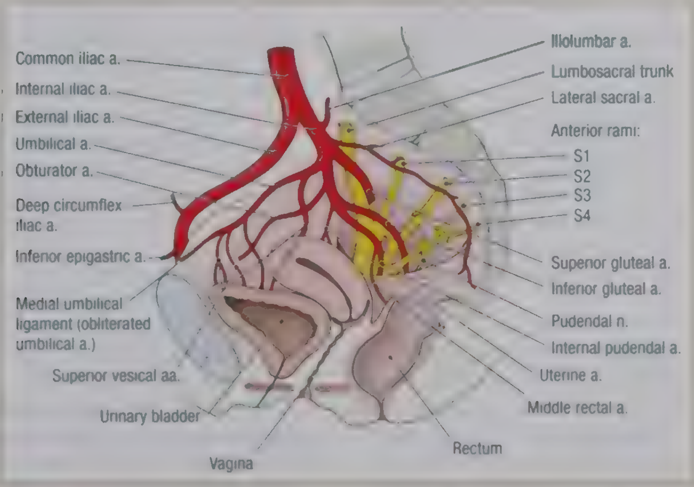

Common iliac a.
Internal iliac a.
External iliac a.
Umbilical a.
Obturator a.
Deep circumflex iliac a.
Inferior epigastric a.
Medial umbilical ligament (obliterated umbilical a.)
Superior vesical aa.
Urinary bladder
Vagina
Iliolumbar a.
Lumbosacral trunk
Lateral sacral a.
Anterior rami:
S1
S2
S3
S4
Superior gluteal a.
Inferior gluteal a.
Pudendal n.
Internal pudendal a.
Uterine a.
Middle rectal a.
Rectum

FIGURE 5.44 ■ Branches of the female internal iliac artery. Midsagittal view.

8. Identify the **lateral sacral artery**, which gives rise to a superior branch and an inferior branch. Observe that the inferior branch passes anterior to the sacral ventral rami. *Note that the lateral sacral artery may arise from a common trunk with the iliolumbar artery.*
9. Identify the last and typically largest branch of the posterior division, the **superior gluteal artery**, which exits the pelvic cavity through the greater sciatic foramen superior to the piriformis muscle.
10. Identify the branches of the **anterior division of the internal iliac artery** beginning with the **umbilical** artery. In the medial umbilical fold, find the **medial umbilical ligament** (the remnant of the umbilical artery) and use blunt dissection to trace it posteriorly to the umbilical artery.
11. Identify and clean several **superior vesical arteries**, which arise from the inferior surface of the umbilical artery and descend to the superolateral part of the urinary bladder.
12. Inferior to the umbilical artery, identify the **obturator artery**, which passes into the obturator canal along with the **obturator nerve**. Find the obturator artery where it enters the obturator canal in the lateral wall of the pelvis and follow the artery posteriorly to its origin. *Note that the obturator artery arises from the external iliac or inferior epigastric arteries in about a quarter of individuals. This* ***aberrant obturator artery*** *crosses the pelvic brim to enter the obturator canal. The aberrant obturator artery is particularly at risk for injury during surgical repair of a femoral hernia.*
13. Follow the anterior division of the internal iliac artery toward the pelvic floor and identify the **inferior gluteal artery**.
14. Observe that the inferior gluteal artery commonly passes out of the pelvic cavity into the gluteal region through the greater sciatic foramen inferior to the piriformis muscle. *Note that the inferior gluteal artery may share a common trunk with the internal pudendal artery, or less commonly, with the superior gluteal artery.*
15. Identify the **uterine artery** coursing along the inferior attachment of the broad ligament.
16. Use blunt dissection to trace the uterine artery to the lateral aspect of the uterus and observe that it passes superior to the ureter. Commonly, the uterine artery divides into a large superior branch to the body and fundus of the uterus and a smaller branch to the cervix and vagina.
17. Observe the close relationship of the lateral part of the vaginal fornix to the uterine artery. *Note that in a living person, the pulsations of the uterine artery may be felt through the lateral part of the vaginal fornix.*
18. Identify the **vaginal artery** and observe that it passes across the floor of the pelvis, inferior to the ureter, to supply the vagina and the urinary bladder. *Note that the male cadaver does not have a vaginal or uterine artery but rather has an inferior vesical artery.*
19. Identify the ureter and observe that it passes between the vaginal artery and the uterine artery.

CLINICAL CORRELATION

### Uterine Artery and Hysterectomy

ATLAS 5.33C

The close proximity of the ureter and the uterine artery near the lateral fornix of the vagina is of clinical importance. During hysterectomy, the uterine artery is tied off and cut. The ureter may be unintentionally clamped, tied off, and cut where it crosses the uterine artery resulting in serious consequences for the corresponding kidney. To recall this relationship, use the mnemonic device "water under the bridge." The "water" is the urine within the ureter, and the "bridge" is the uterine artery.

20. Identify the **internal pudendal artery** anterior to the inferior gluteal artery. Observe that the internal pudendal artery exits the pelvic cavity through the greater sciatic foramen but stays more medial than the inferior gluteal artery because it will enter the lesser sciatic foramen to reach the perineum. *Note that the internal pudendal artery often arises from a common trunk with the inferior gluteal artery.*

## Female Pelvic Nerves

ATLAS 5.13, 5.42B, 5.42C; VIDEO 5.11.2

1. Refer to FIGURE 5.45.
2. Use your fingers to free the rectum from the anterior surface of the sacrum and coccyx.
3. Retract the rectum medially and identify the **sacral plexus** of nerves. Observe that the sacral plexus is closely related to the anterior surface of the piriformis muscle.
4. Just lateral to the sacral promontory, identify and clean the **lumbosacral trunk** (anterior rami of L4 and L5) and verify that it joins the sacral plexus.
5. Inferior to the lumbosacral trunk, identify the anterior rami of S2 and S3, which emerge between the proximal attachments of the piriformis muscle.
6. Identify the **sciatic nerve** and observe that it is formed by the anterior rami of spinal nerves L4–S3. The sciatic nerve exits the pelvis by passing through the greater sciatic foramen to enter the gluteal region, usually inferior to the piriformis muscle.
7. Observe that the **superior gluteal artery** usually passes between the **lumbosacral trunk** and the **anterior ramus of spinal nerve S1** and exits the pelvis by passing superior to the piriformis muscle.

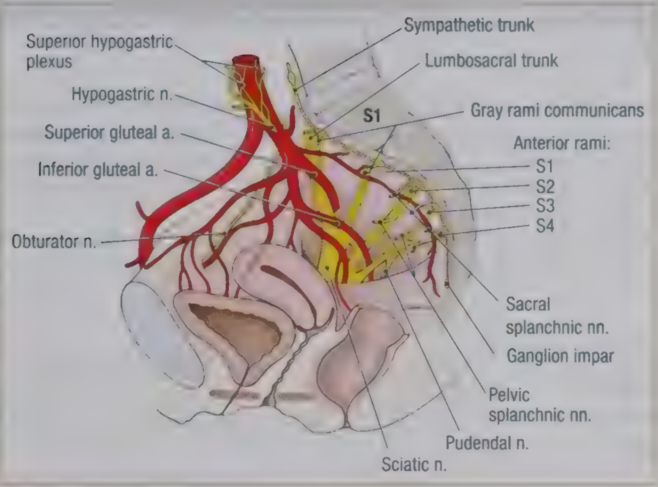


FIGURE 5.45 ● Sacral and autonomic nerve plexuses in the female. Midsagittal view.

8. Observe that the **inferior gluteal artery** usually passes between the anterior rami of spinal nerves S2 and S3, but may pass between the anterior rami S1 and S2, to exit the pelvis inferior to the piriformis muscle.
9. Identify the **pudendal nerve** and observe that it is formed by contributions from the anterior rami of spinal nerves S2, S3, and S4. *Note that the pudendal nerve exits the pelvis by passing inferior to the piriformis muscle, through the greater sciatic foramen, where it then enters the perineum by passing through the lesser sciatic foramen.*
10. Identify the **pelvic splanchnic nerves (nervi erigentes)**. Observe that pelvic splanchnic nerves are branches of the anterior rami of spinal nerves S2, S3, and S4. *Note that pelvic splanchnic nerves carry presynaptic parasympathetic axons for innervation of pelvic organs and the distal gastrointestinal tract from the left colic flexure to the anal canal.*
11. Identify the **sacral portion of the sympathetic trunk** located on the anterior surface of the sacrum, medial to the ventral sacral foramina. Observe that the **sympathetic trunk** continues from the abdominal region into the pelvis and that the two sides join in the midline near the level of the coccyx to form the **ganglion impar**.
12. Identify the **gray rami communicantes**, which connect the sympathetic ganglia to the sacral anterior rami. *Note that each gray ramus communicans carries postsynaptic sympathetic fibers to an anterior ramus for distribution to the lower extremity and perineum.*
13. Identify the **sacral splanchnic nerves** arising from two or three of the sacral sympathetic ganglia and observe that they pass directly to the **inferior hypogastric plexus**. *Note that sacral splanchnic nerves carry sympathetic fibers that distribute to the pelvic viscera.*
14. On the right side of the pelvic cavity, make an effort to follow the hypogastric plexus superiorly toward the condensation of the plexus into the **right hypogastric nerve**. Use an illustration to identify the **superior hypogastric plexus** and review the origins of the autonomics in both the superior and inferior hypogastric plexuses.

## Dissection Follow-up

1. Review the abdominal aorta and its terminal branches.
2. Use the dissected specimen to review the branches of the internal iliac artery. Review the region supplied by each branch.
3. Review the relationship of the uterine and vaginal arteries to the ureter.
4. Review the formation of the sacral plexus and the branches that were dissected in the pelvis.
5. Use the dissected specimen to review the course of the pudendal nerve from the pelvic cavity to the urogenital triangle.
6. Return the reflected tissue back to anatomical position.

## FEMALE PELVIC DIAPHRAGM

### Dissection Overview

The pelvic diaphragm is the muscular floor of the pelvic cavity and is formed by the levator ani muscle and coccygeus muscle, plus the fasciae covering their superior and inferior surfaces. The pelvic diaphragm extends from the pubic symphysis to the coccyx posteriorly. Laterally, the pelvic diaphragm is attached to the fascia covering the obturator internus muscle. The urethra and vagina and the anal canal pass through midline openings in the pelvic diaphragm called the urogenital hiatus and anal hiatus, respectively.

The order of dissection will be as follows: The pelvic viscera will be retracted medially. The obturator internus, tendinous arch of the levator ani, and the levator ani will be identified. The urethra, vaginal canal, and anal canal will be cut and the pelvic viscera reflected.

### Dissection Instructions

#### Female Pelvic Diaphragm

ATLAS 5.10, 5.11, 5.12; VIDEO 5.12.1

***Dissection Note:*** Perform the following dissection sequence on only one side of the cadaver. If the left lower limb was removed during the bisection of the pelvis, it is recommended that the deep dissection be performed on the left side to preserve the continuity of the vasculature into the abdominal cavity on the right side.

1. Refer to FIGURE 5.46A.
2. Retract the rectum, vagina and uterus, and urinary bladder medially and identify the **pelvic diaphragm**.
3. Use blunt dissection to remove any remaining fat and connective tissue from the superior surface of the pelvic diaphragm.
4. Locate the **obturator canal** piercing the obturator internus by identifying and following the obturator artery and nerve.
5. Palpate the medial surface of the ischial spine through the levator ani and identify the **tendinous arch of the levator ani muscle**.
6. Observe that the tendinous arch lies just inferior to a line connecting the ischial spine and the obturator canal. *Note that the tendinous arch is a thickening in the obturator fascia and the origin of part of the levator ani muscle.*
7. Identify the three components of the **levator ani muscle** by their anterior attachments. Learn, but do not dissect, their posterior attachments.
8. Refer back to FIGURE 5.42 and FIGURE 5.46B.
9. Identify the **puborectalis muscle** (paired) attaching anteriorly to the body of the pubis and posteriorly to the puborectalis muscle of the opposite side (in a midline raphe). The puborectalis muscles form the margin of the urogenital hiatus and a "puborectal sling," which maintains the **anorectal flexure** of the rectum. *Note that during defecation, the puborectalis muscles relax, the anorectal flexure straightens, and the elimination of fecal matter is facilitated.*
10. Identify the **pubococcygeus muscle** (paired) attaching from the body of the pubis anteriorly to the coccyx and the **anococcygeal raphe (ligament)** posteriorly.
11. Identify the **iliococcygeus muscle** (paired) attaching from the tendinous arch anterolaterally to the coccyx and the anococcygeal raphe posteriorly. *Note that the levator ani muscle supports the pelvic viscera and resists increases in intra-abdominal pressure.*
12. Identify the **coccygeus muscle** (paired), which completes the pelvic diaphragm posteriorly. Observe that the anterior attachment of the coccygeus muscle is the ischial spine and that its posterior attachment is the lateral border of the coccyx and the lowest part of the sacrum.
13. Place the fingers of one hand in the ischioanal fossa inferior to the pelvic diaphragm and the fingers of the other hand on the superior surface of the pelvic diaphragm. Palpate the pelvic diaphragm between both hands and appreciate its thinness.
14. Turn the left lower limb and observe that the **obturator internus muscle** forms the lateral wall of the ischioanal fossa and perineum inferior to the pelvic diaphragm and the lateral wall of the pelvic cavity superior to the pelvic diaphragm.

***Dissection Note:*** The medial attachment of the obturator internus muscle is the margin of the obturator foramen and inner surface of the obturator membrane. The lateral attachment of the obturator internus muscle is the greater trochanter of the femur and will be studied when the gluteal region is dissected.

15. Observe that the urethra and vagina and the anal canal pass through midline openings in the pelvic diaphragm called the **urogenital hiatus** and **anal hiatus**, respectively.
16. If the muscles forming the pelvic diaphragm remain difficult to see, make an incision through the inferior aspect of the urinary bladder, vaginal canal, and anal canal and detach the viscera from the pelvic floor. Leave the viscera attached to the neurovascular structures so the relationships are maintained for later review.
17. Review the general pattern of lymphatic drainage of the pelvis and the location of the **common iliac** nodes, the **external iliac nodes**, the **internal iliac nodes**, the **sacral nodes**, and the **lumbar nodes**.

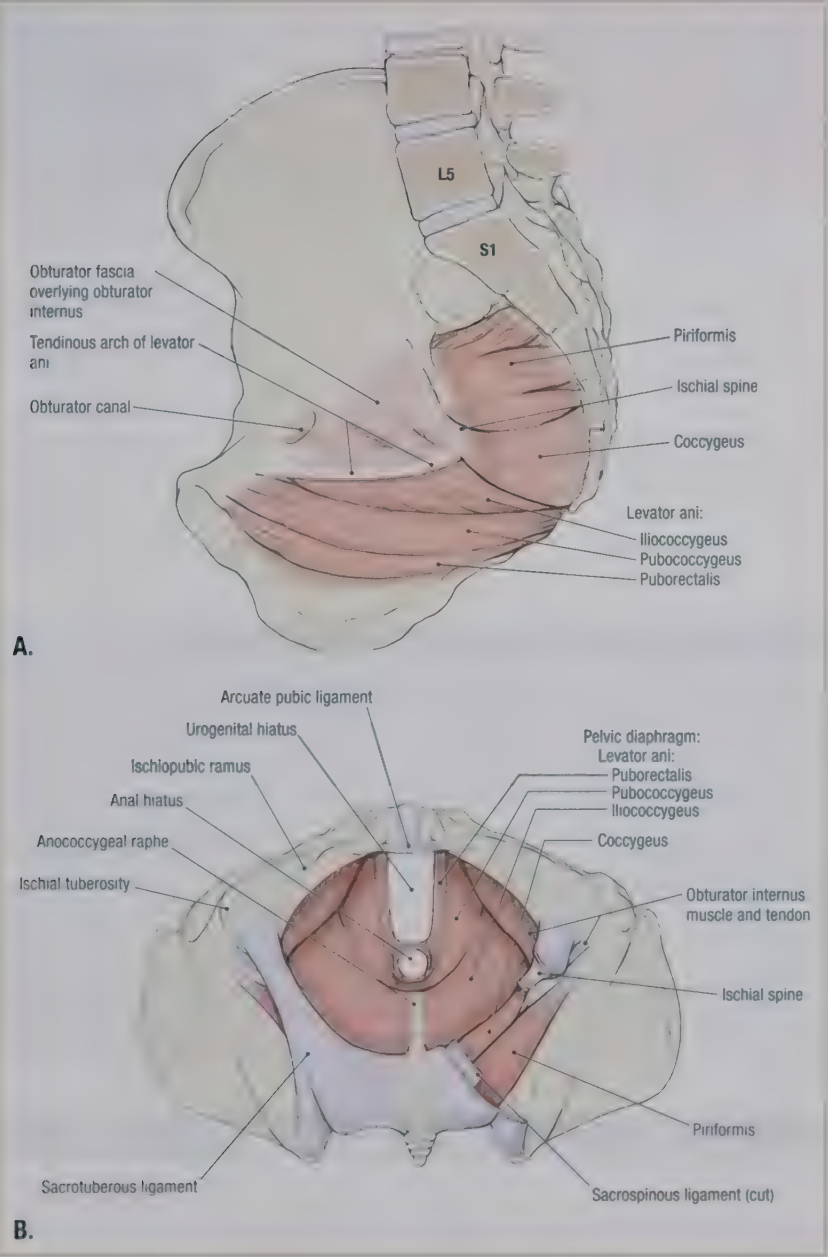
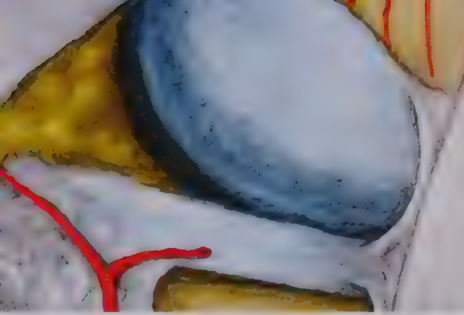

L5
S1
Obturator fascia overlying obturator internus
Tendinous arch of levator ani
Obturator canal
Piriformis
Ischial spine
Coccygeus
Levator ani:
Iliococcygeus
Pubococcygeus
Puborectalis
A.
Arcuate pubic ligament
Urogenital hiatus
Ischiopubic ramus
Anal hiatus
Anococcygeal raphe
Ischial tuberosity
Pelvic diaphragm:
Levator ani:
Puborectalis
Pubococcygeus
Iliococcygeus
Coccygeus
Obturator internus muscle and tendon
Ischial spine
Piriformis
Sacrotuberous ligament
Sacrospinous ligament (cut)
B.

FIGURE 5.46 ● Female pelvic diaphragm. **A.** Midsagittal view. **B.** Inferior view.

## Dissection Follow-up

1. Use the dissected specimen to review the proximal attachment and action of each muscle of the pelvic diaphragm.
2. Review the relationship of the branches of the internal iliac artery to the pelvic diaphragm.
3. Review the relationship of the sacral plexus to the pelvic diaphragm.
4. Review the role played by the pelvic diaphragm in forming the boundary between the pelvic cavity and the perineum and in supporting the pelvic and abdominal viscera.
5. Compare the lymphatic drainage of the perineal structures to the lymphatic drainage of the ovary.
6. Review the formation of the thoracic duct to complete your understanding of the lymph drainage from this region.
7. Visit a dissection table with a male cadaver and perform a complete review of the dissected male pelvis.



## CHAPTER 6

# The Lower Limb

**REFERENCES**

ATLAS = *Grant's Atlas of Anatomy*, 15th ed., figure number

VIDEO = *Grant's Dissection Videos*, video sequence number

The functional requirements of the lower limb are weight bearing, locomotion, and maintenance of equilibrium. Although the upper and lower limbs develop with a similar pattern of organization, the lower limb is constructed for strength at the cost of mobility. The lower limb is divided into four parts: hip, thigh, leg, and foot. It is worth noting that the term *leg* refers only to the portion of the lower limb between the knee and ankle, not to the entire lower limb.

**CLINICAL CORRELATIONS**

During the course of your dissection protocol, you may encounter anatomical variations, clinical conditions, disease processes, or medical devices in your cadaveric donor. The following select clinical correlations will be described in more detail throughout this chapter.

**The Lower Limb**

1. Varicose Veins and Saphenous Cut Down, see the **Superficial Fascia of the Anterior Lower Limb** sequence. ATLAS 6.11A, 6.12B
2. Femoral Triangle and Femoral Hernia, see the **Femoral Triangle** sequence. ATLAS 6.18
3. Patellar Tendon (Quadriceps) Reflex, see the **Tensor of Fascia Lata Muscle** sequence. ATLAS 6.7, 6.45
4. Intragluteal Injections, see the **External Rotators of the Hip** sequence. ATLAS 6.31
5. Sciatic Nerve Injury, see the **Posterior Thigh** sequence. ATLAS 6.33A, 6.33B
6. Common Fibular Nerve Injury, see the **Anterior Compartment of the Leg** sequence. ATLAS 6.62B
7. Neck of the Femur Fracture, see the **Hip Joint** sequence. ATLAS 6.40
8. Knee Injuries, see the **Knee Joint Posterior Approach** sequence. ATLAS 6.47, 6.48
9. Ankle Injuries, see the **Ankle Joint** sequence. ATLAS 6.82

## SUPERFICIAL FASCIA OF THE LOWER LIMB

### Dissection Overview

The superficial fascia of the lower limb contains fat, lymphatics, superficial veins, and cutaneous nerves. In the living body, the superficial veins of the lower limb may be visible through the skin and used for venipuncture or cannulation. In the cadaver, the superficial veins are not conspicuous.

The order of dissection will be as follows: The entire lower limb will be skinned. The superficial veins and cutaneous nerves will be dissected. The subcutaneous connective tissue and fat will be removed leaving selected superficial veins and cutaneous nerves intact. The deep fascia of the thigh will be studied.

## Skeletal Anatomy

Refer to an articulated skeleton or disarticulated lower limb skeleton to identify the following skeletal features.

### Anterior Hip Bone

ATLAS 6.2A, 6.27A

1. Refer to FIGURE 6.1.
2. Identify the three bones comprising the hip bone from an anterior view: **pubis**, **ischium**, and **ilium**.
3. Observe that the three bones of the hip fuse within the **acetabulum**, the cuplike depression forming the socket of the hip joint. *Note that the point of fusion of the three bones in the acetabulum is referred to as the triradiate cartilage in youth and adolescents, typically not visible in the adult after skeletal fusion.*
4. On the anterior aspect of the pelvis, identify both the **anterior superior iliac spine (ASIS)** and the **anterior inferior iliac spine (AIIS)** of the ilium.
5. Follow the curve of the pelvic inlet along the **pecten pubis** to the **pubic tubercle**.
6. Align the pelvis in anatomical position and verify that the pubic tubercle and ASIS are aligned in a coronal plane.
7. Identify the **obturator foramen** and observe that it is bounded superiorly by the **superior pubic ramus** and inferomedially by the ischiopubic ramus, composed of the **inferior pubic ramus** and the **ischial ramus**.

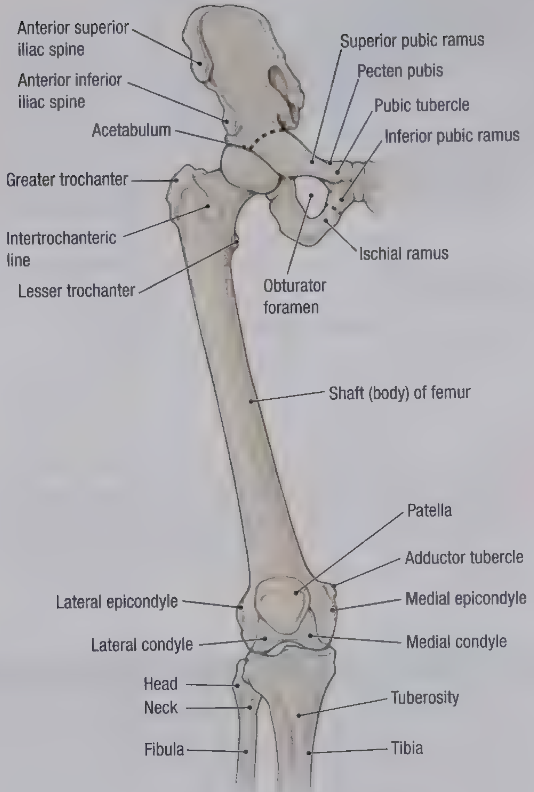

Anterior superior iliac spine
Anterior inferior iliac spine
Acetabulum
Greater trochanter
Intertrochanteric line
Lesser trochanter
Superior pubic ramus
Pecten pubis
Pubic tubercle
Inferior pubic ramus
Ischial ramus
Obturator foramen
Shaft (body) of femur
Patella
Adductor tubercle
Medial epicondyle
Medial condyle
Lateral epicondyle
Lateral condyle
Head
Neck
Fibula
Tuberosity
Tibia

FIGURE 6.1 ■ Skeleton of the right hip, thigh, and knee. Anterior view.

### Anterior Femur

ATLAS 6.2A, 6.27A

1. Refer to FIGURE 6.1.
2. On the superolateral aspect of the femur proximally, identify the **greater trochanter**.
3. On the anterior aspect of the proximal femur, follow the **intertrochanteric line** inferomedially from the greater trochanter to the **lesser trochanter**.
4. On the distal femur laterally, identify the **lateral epicondyle** superior to the **lateral condyle**.
5. On the distal femur medially, identify the **adductor tubercle** on the **medial epicondyle** superior to the **medial condyle**.

### Anterior Proximal Tibia, Fibula, and Patella

ATLAS 6.2A

1. Refer to FIGURE 6.1.
2. On the proximal tibia, identify the **medial** and **lateral condyles**.
3. Observe that the **fibular head** articulates with the tibia inferior to the lateral condyle but does not articulate with the femur.
4. On the anterior surface of the proximal tibia, identify the **tibial tuberosity**.
5. On the **patella**, identify the anterior surface and the articular surface (posterior).

## Surface Anatomy

The surface anatomy of the lower limb may be studied on a living subject or on a cadaver. On the cadaver, note that fixation of tissue during embalming may make it difficult to distinguish bone from well-preserved soft tissues in some specimens.

## Anterior Lower Limb

ATLAS 6.1A

1. Refer to FIGURE 6.2.
2. Place the cadaver in the supine position.
3. Beginning on the lateral aspect of the hip, palpate the **iliac crest**.
4. Follow the path of the iliac crest anteriorly and identify the **ASIS** on the anterior aspect of the hip. *Note that the ASIS should be palpable even in larger cadavers because little Camper's fascia develops at this location.*
5. Move your fingers inferomedially from the ASIS to the pubic region following the path of the inguinal ligament and palpate the **pubic tubercle**.
6. In the midline of the lower limb, between the thigh and leg, palpate the "knee cap" or **patella** on the anterior aspect of the knee.
7. Observe that the patella has a relatively small degree of mobility in the fixed tissue of the embalmed cadaver compared to a living individual.
8. At the knee, palpate the **medial femoral epicondyle** and **lateral femoral epicondyle** on the medial and lateral aspects of the knee, respectively.
9. On the anterior aspect of the leg beginning just below the knee, palpate the **tibial tuberosity** and then, continuing inferiorly toward the ankle, palpate the **anterior border of the tibia**.
10. At the ankle, palpate the **medial malleolus** and the **lateral malleolus** on the medial and lateral aspects of the ankle, respectively.

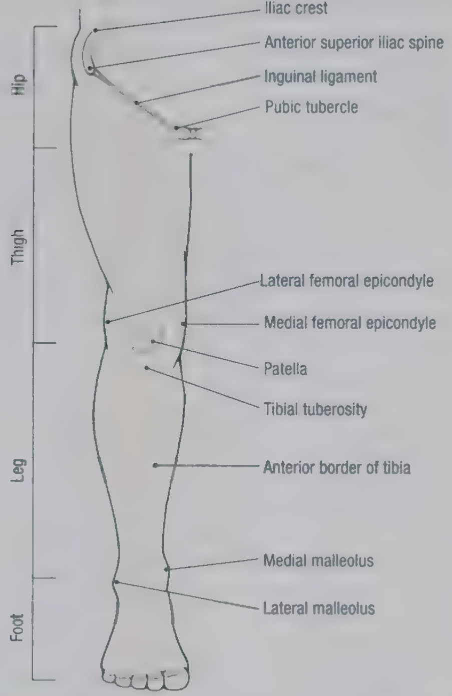


FIGURE 6.2 ■ Surface anatomy of the right lower limb. Anterior view.

## Dissection Instructions

***Dissection Note:*** Prior to commencing with skin incisions, note that the superficial veins and cutaneous nerves are easily damaged in the lower limb if skin incisions are made too deeply. It is thus recommended that along the medial and anterior surface of the limb, a partial-thickness skinning technique be implemented.

### Skin Incisions of the Lower Limb

VIDEO 6.1.1

1. Refer to FIGURE 6.3A.
2. Place the cadaver in the supine position.
3. Make an incision from the ASIS (F) along the inguinal ligament (Q) to the pubic tubercle. *Note that if the abdomen has previously been dissected, this incision has been made.*
4. Extend the cut from the pubic tubercle inferiorly along the medial side of the thigh (D). *Note that if the perineum has previously been dissected, this incision has been made.*
5. Elevate the skin overlying the inguinal ligament (Q) to verify the depth of the skin and subcutaneous tissue of the region.
6. Make a vertical incision from the midpoint of the inguinal ligament (Q) inferiorly through the thigh bisecting the skin overlying the patella until you reach the tibial tuberosity (R) in the leg.

***Dissection Note:*** While making the skin incision along the thigh, make an effort to preserve the underlying superficial veins and pay attention to not cut too deeply through the thin skin overlying the knee and thus damage the underlying tendons.

7. Extend the vertical incision from the tibial tuberosity (R) to the anterior aspect of the leg just superior to the ankle (S) following the path of the anterior border of the tibia.
8. Continue the vertical incision from the leg along the dorsum of the foot until a point just proximal to the toes (G).
9. Carefully make a shallow transverse incision across the dorsum of the foot just proximal to the webs of the toes (H to H). *Note that the skin is very thin on the dorsum of the foot, and care must be taken to not cut too deeply.*

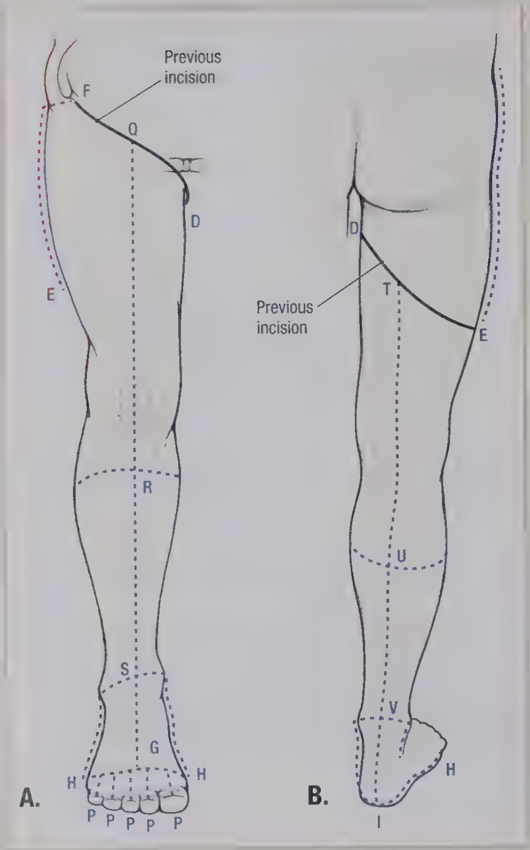


FIGURE 6.3 ■ Skin incisions of the right lower limb. **A.** Anterior view. **B.** Posterior view.

10. Make a transverse skin incision from the anterior aspect of the leg (S) medially to the medial malleolus and laterally to the lateral malleolus.
11. Make a transverse skin incision from the tibial tuberosity (R) around the anterior aspect of the leg both medially and laterally to the periphery of the limb.
12. Reflect the skin from the lower limb beginning at the vertical incision at the midline of the inguinal ligament (Q) to the dorsum of the foot (G) medially and laterally as far as possible from the supine position.
13. Make additional transverse skin incisions as needed to speed up the skinning process by dividing the skinned regions into smaller portions.
14. Detach the skin from the dorsum of the foot peripherally along the medial and lateral aspects of the foot (I to H) making an effort to not disrupt the thick skin of the sole of the foot.
15. If the toes will be dissected, make a cut along the dorsal midline of each toe from the horizontal line across the webbing of the toes (H to H) to the proximal end of the nail (P) and remove the skin from the dorsal surface of each digit.
16. Refer to FIGURE 6.3B.
17. Place the cadaver in the prone position.
18. If the skin of the gluteal region has not previously been removed, work from medial to lateral and detach the skin from the gluteal region and lateral side of the hip (F to E).
19. Make an incision along the posterior midline of the thigh beginning at a point inferior to the gluteal folds (T) to a point inferior to the knee (U) that bisects the horizontal incision, which began at the tibial tuberosity (R).
20. Continue the vertical incision from just below the knee (U) to a point posterior to the ankle overlying the calcaneal tendon (V).
21. Carefully extend the vertical incision from the posterior aspect of the ankle (V) along the path of the calcaneal tendon paying attention to not cut too deeply until you reach the inferior aspect of the heel (I).
22. Extend the transverse skin incisions begun around the anterior surface of the limb at both the knee and ankle to join the vertical incision along the posterior aspect of the limb (T to I).
23. Begin from the posterior midline (T to I) work both medially and laterally to reflect large portions of the skin to the peripheral aspects of the limb.
24. Remove the skin from the thigh and leg and place it in the tissue container. Do not yet remove the skin from the sole of the foot.

***Dissection Note:*** Reflecting the skin with portions still attached will block views of the underlying anatomy, thus it is recommended to completely remove the skin. If the skin is removed in large portions, it may, however, be used later to wrap the neck postdissection to prevent desiccation.

## Superficial Fascia of the Posterior Lower Limb

ATLAS 6.6B, 6.15; VIDEO 6.1.2

1. Refer to FIGURE 6.4B.
2. With the cadaver in the prone position, examine the structures contained in the **superficial fascia** of the posterior lower limb.
3. Identify and clean the **small (lesser) saphenous vein** where it passes posterior to the lateral malleolus at the ankle. Observe that the small saphenous vein arises from the lateral end of the **dorsal venous arch of the foot**.
4. Use blunt dissection to follow the small saphenous vein superiorly and observe that it pierces the deep fascia overlying the popliteal fossa to drain into the popliteal vein.

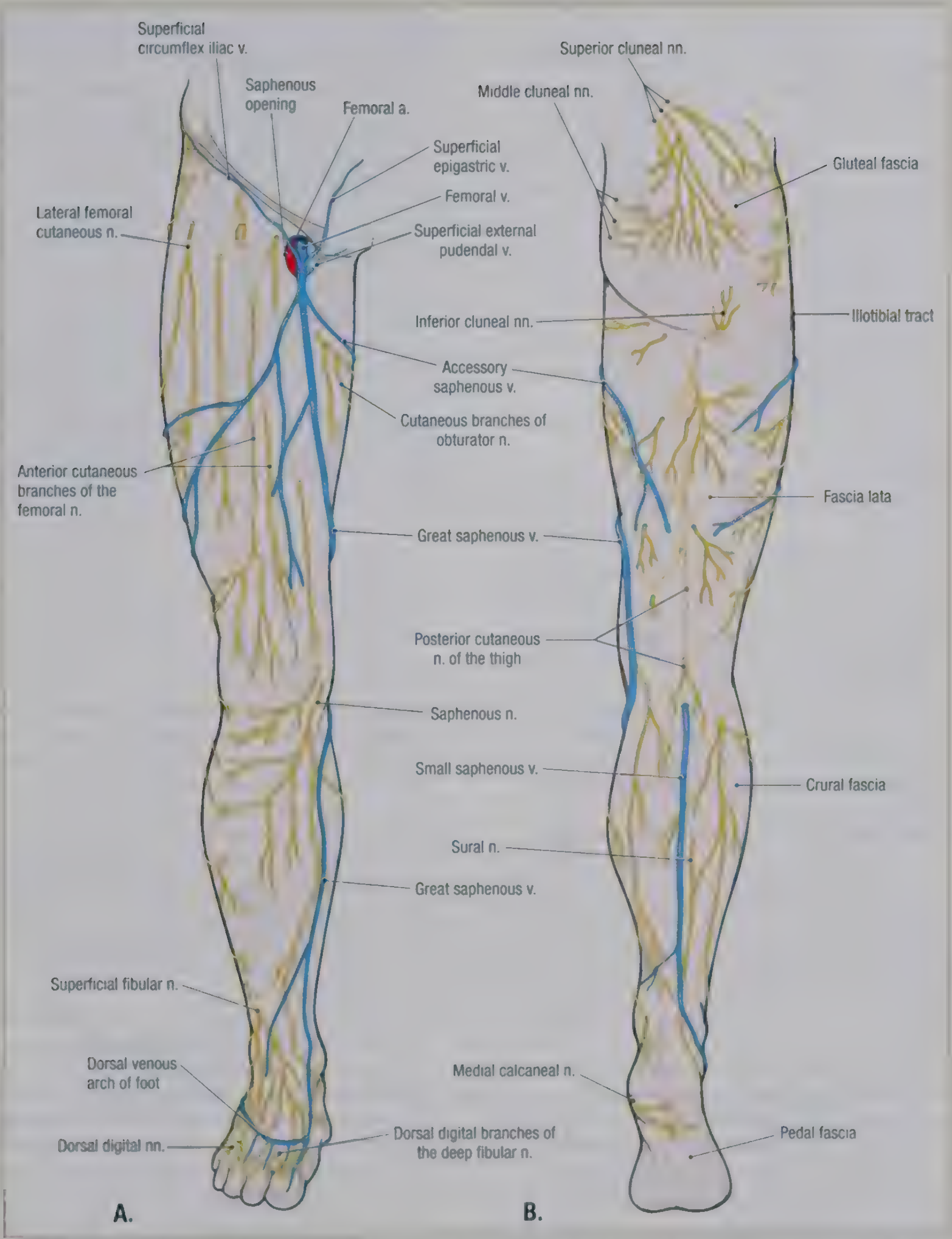

Superficial circumflex iliac v.
Saphenous opening
Femoral a.
Superficial epigastric v.
Femoral v.
Superficial external pudendal v.
Lateral femoral cutaneous n.
Accessory saphenous v.
Cutaneous branches of obturator n.
Anterior cutaneous branches of the femoral n.
Great saphenous v.
Saphenous n.
Great saphenous v.
Superficial fibular n.
Dorsal venous arch of foot
Dorsal digital nn.
Dorsal digital branches of the deep fibular n.
A.
Superior cluneal nn.
Middle cluneal nn.
Gluteal fascia
Inferior cluneal nn.
Iliotibial tract
Fascia lata
Posterior cutaneous n. of the thigh
Small saphenous v.
Crural fascia
Sural n.
Medial calcaneal n.
Pedal fascia
B.

FIGURE 6.4 ■ Cutaneous nerves, superficial veins, and deep fascia of the right lower limb. **A.** Anterior view. **B.** Posterior view.

5. Identify the **sural nerve** on the posterior aspect of the leg. Observe that the sural nerve pierces the deep fascia halfway down the posterior aspect of the leg and courses parallel to the small saphenous vein. *Note that the sural nerve innervates the skin of the lateral aspect of the ankle and foot.*
6. Identify the **posterior cutaneous nerve of the thigh** overlying the posterior aspect of the popliteal fossa. The posterior cutaneous nerve of the thigh is difficult to follow superiorly because it lies deep to the deep fascia. *Note that branches of this nerve pierce the deep fascia to supply the skin on the posterior surface of the thigh and popliteal fossa.*
7. Identify the **cluneal nerves**, which innervate the skin of the gluteal region if they have not already been cut or removed.
8. Observe that the **superior cluneal nerves** (posterior rami of L1–L3) innervate the upper buttock.
9. Observe that the **middle cluneal nerves** (posterior rami of S1–S3) innervate the middle part of the buttock.
10. Observe that the **inferior cluneal nerves** (posterior rami of S2–S3) and branches of the **posterior cutaneous nerve of the thigh** (posterior rami of S1–S3) wrap around the inferior border of the gluteus maximus muscle and innervate the skin over the lower part of the buttock.
11. Remove all remnants of **superficial fascia** from the posterior aspect of the gluteal region, thigh, and leg while preserving the deep fascia, cutaneous nerves, and superficial veins that have been dissected.

## Superficial Fascia of the Anterior Lower Limb

ATLAS 6.6A, 6.11A, 6.15; VIDEO 6.1.3

1. Refer to FIGURE 6.4A.
2. Turn the cadaver to the supine position.
3. Identify and clean the **great saphenous vein** at the ankle where it courses anterior to the medial malleolus.
4. Follow the great saphenous vein into the foot and observe that it arises from the medial end of the **dorsal venous arch of the foot.**
5. Use blunt dissection to follow the great saphenous vein toward the knee and observe that it passes posterior to the medial epicondyle of the femur. *Note that the location of the great saphenous vein posterior to the knee reduces tension on the vessel when the knee is flexed and may usually be found about a hand's span posterior to the patella.*
6. Continue to follow the great saphenous vein into the thigh and observe that beginning at the level of the knee, it courses anterolaterally to eventually lie on the anterior surface of the proximal thigh where it drains into the femoral vein, but do not yet follow it into its point of drainage.
7. Along the course of the great saphenous vein, identify the many unnamed superficial veins, which drain into it, as well as the **perforating veins**, which connect the great saphenous vein to the deep venous system.
8. On the medial aspect of the thigh, identify the **accessory saphenous vein**, a named tributary that drains the superficial fascia and skin of the medial side of the thigh.
9. About 4 cm inferior to the inguinal ligament, observe that the great saphenous vein pierces the **saphenous opening (saphenous hiatus)** and drains into the femoral vein.

***Dissection Note:*** The saphenous opening, a thinning in the deep fascia of the thigh (fascia lata), will be dissected later. Do not disrupt the saphenous opening at this time.

10. At the saphenous opening, observe the **superficial external pudendal vein**, the **superficial epigastric vein**, and the **superficial circumflex iliac vein** join the great saphenous vein.
11. In the proximal thigh, identify the **lateral femoral cutaneous nerve** where it passes deep to the lateral end of the inguinal ligament to innervate the skin of the lateral thigh.
12. Identify the **anterior cutaneous branches of the femoral nerve,** which innervate the skin of the anterior thigh. Observe that the cutaneous branches of the femoral nerve enter the superficial fascia lateral to the great saphenous vein.
13. On the medial side of the knee, identify the **saphenous nerve** where it pierces the deep fascia to accompany the great saphenous vein into the leg. *Note that the saphenous nerve is a branch of the femoral nerve and innervates the skin on the anterior and medial sides of the leg and the medial side of the ankle and foot.*
14. Medial to the great saphenous vein, identify the **cutaneous branches of the obturator nerve**, which innervate the skin of the medial thigh.
15. In the distal third of the leg, identify the **superficial fibular nerve** where it pierces the deep fascia of the leg, the **crural fascia**, superior to the lateral malleolus and follow it onto the dorsum of the foot. *Note that the superficial fibular nerve innervates the dorsum of the foot and sends dorsal digital nerves to the skin of the toes.*
16. On the dorsum of the foot, identify the **dorsal digital branches of the deep fibular nerve** between the 1st toe and the 2nd toe. *Note that the innervation pattern between the toes is used for the assessment of deep fibular nerve function.*

CLINICAL CORRELATION

### Varicose Veins and Saphenous Cut Down

ATLAS 6.11A, 6.12B

Superficial veins and perforating veins have valves that prevent the backflow of blood. If the valves in the veins become incompetent, the veins distend and become tortuous, a condition known as *varicose veins.*

Clinically, the great saphenous vein may be used as a point of entrance for cannulation to provide a patient with prolonged administration of drugs, blood, or electrolytes. The great saphenous vein is accessed by making a small incision anterior to the medial malleolus, a procedure known as saphenous cut down. Portions of the great saphenous vein may also be removed and used as graft vessels in coronary bypass surgery, although the vessel direction would need to be reversed so the valves do not prevent arterial blood flow.

17. Refer to FIGURE 6.5.
18. In the proximal thigh, make an effort to identify the **horizontal group of superficial inguinal lymph nodes** located about 2 cm inferior to the inguinal ligament.
19. Identify the **vertical group of superficial inguinal lymph nodes** encircling the proximal end of the **great saphenous vein.** *Note that the superficial inguinal lymph nodes collect lymph from the lower limb, inferior part of the anterior abdominal wall, gluteal region, perineum, and external genitalia.*
20. Identify the **deep inguinal lymph nodes** through the fascia overlying the **saphenous opening**, but do not yet dissect them. *Note that the deep inguinal lymph nodes receive the lymphatic drainage from the superficial nodes and drain through the femoral canal into the abdomen deep to the inguinal ligament.*

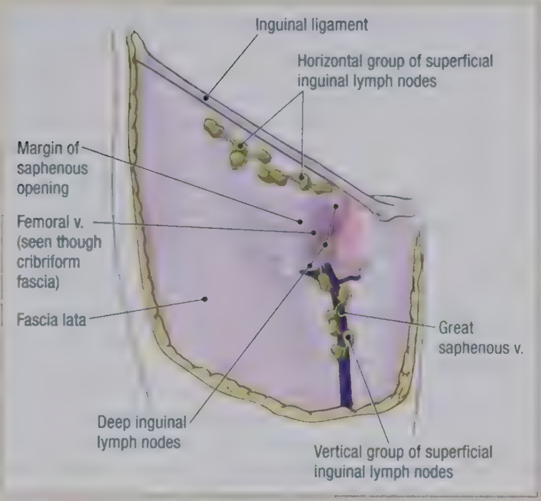

Inguinal ligament
Horizontal group of superficial inguinal lymph nodes
Margin of saphenous opening
Femoral v. (seen though cribriform fascia)
Fascia lata
Great saphenous v.
Deep inguinal lymph nodes
Vertical group of superficial inguinal lymph nodes

FIGURE 6.5 ● Saphenous opening and superficial inguinal lymph nodes. Anterior view.

21. Remove the remnants of superficial fascia from the anterior thigh, leg, and foot making an effort to preserve the superficial veins, cutaneous nerves, and deep fascia.
22. Refer back to FIGURE 6.4.
23. Examine the deep fascia of the lower limb beginning with the **gluteal fascia** overlying the gluteal muscles.
24. Progress inferiorly and identify the **fascia lata** in the thigh. Observe that the fascia lata thickens laterally to form the **iliotibial tract (IT band)**.
25. Identify the **crural fascia**, the deep fascia of the leg, and observe how tight and thick the crural fascia is compared to the fascia lata.
26. Identify the **pedal fascia**, the deep fascia of the foot.

## Dissection Follow-up

1. Trace the course of the superficial veins from distal to proximal and note where perforating veins drain deeply.
2. Review the location and pattern of distribution of each cutaneous nerve you have dissected in the lower limb.
3. Review the extent and bony attachments of the deep fascia and name its parts.
4. Review the lymphatic drainage of the lower limb.

# ANTERIOR COMPARTMENT OF THE THIGH

## Dissection Overview

The fascia lata is connected to the femur by intermuscular septa to form the three fascial compartments of the thigh: anterior (extensor), medial (adductor), and posterior (flexor) compartments as shown in FIGURE 6.6. The muscles found within each compartment receive motor innervation primarily through a single nerve. Thus, the anterior compartment is related to the femoral nerve, the medial compartment to the obturator nerve, and the posterior compartment to the branches of the sciatic nerve. The muscles located on the borders of two compartments receive dual innervation and thus are often categorized differently in various texts.

The anterior compartment of the thigh contains the iliopsoas, the sartorius, and the quadriceps femoris muscle (rectus femoris, vastus lateralis, vastus intermedius, and vastus medialis). For ease of dissection, the pectineus muscle and the tensor of the fascia lata muscle will be dissected along with the other muscles of the anterior compartment of the thigh. The femoral artery, the major blood supply to the lower limb, and the femoral nerve, along with many of their branches, pass through the anterior compartment of the thigh.

The order of dissection will be as follows: The fascia lata of the thigh will be reviewed, and the saphenous opening will be studied. The anterior surface of the superior part of the fascia lata will be opened to expose the femoral triangle. The femoral triangle will be dissected, and its vascular contents will be followed distally. The sartorius muscle will be identified, and the adductor canal will be dissected. The anterior surface of the inferior part of the fascia lata will be opened, and the remaining anterior thigh muscles will be studied.

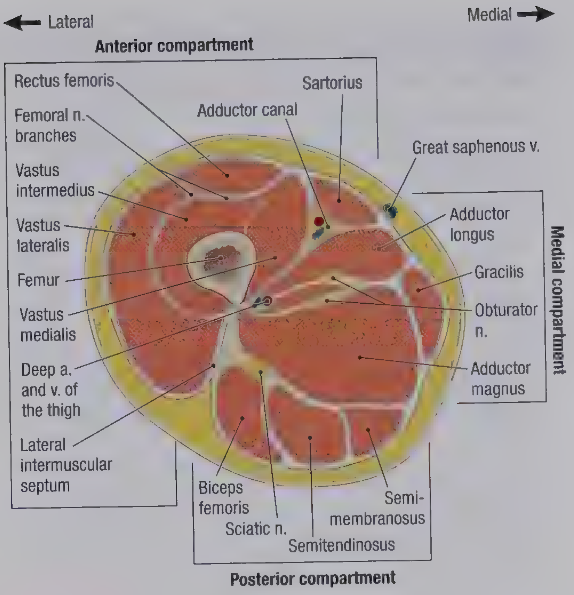

Lateral
Medial
Anterior compartment
Rectus femoris
Sartorius
Femoral n. branches
Adductor canal
Great saphenous v.
Vastus intermedius
Adductor longus
Vastus lateralis
Medial compartment
Gracilis
Femur
Obturator n.
Vastus medialis
Adductor magnus
Deep a. and v. of the thigh
Lateral intermuscular septum
Biceps femoris
Semi-membranosus
Sciatic n.
Semitendinosus
Posterior compartment

FIGURE 6.6 ● Axial section through the right thigh. Inferior view.

# Dissection Instructions

## Saphenous Opening

ATLAS 6.16; VIDEO 6.2.1

1. Refer to FIGURE 6.7.
2. Remove any remnants of superficial fascia on the anterior surface of the fascia lata.
3. Remove the superficial inguinal lymph nodes around the saphenous opening while preserving the great saphenous vein.
4. Follow the great saphenous vein superiorly and observe that it passes through the **saphenous opening** approximately 4 cm inferior to the inguinal ligament.
5. Use a probe to dissect the connective tissue around the great saphenous vein where it penetrates the fascia lata and define the margin of the **saphenous opening**.
6. Observe that the saphenous opening is a natural defect in the fascia lata that is covered with a relatively thin layer of fascia.
7. Trace the great saphenous vein through the saphenous opening and observe that it drains into the anterior aspect of the **femoral vein**.
8. Identify the path of the sartorius muscle coursing deep to the fascia lata.
9. Use scissors to make a vertical incision through the fascia lata from the saphenous opening to the **sartorius muscle** (**Cut 1**).
10. Use scissors to make a horizontal cut through the fascia lata parallel to the inguinal ligament from the superior margin of the saphenous opening to a point directly inferior to the **ASIS** (**Cut 2**).
11. Use scissors to make a second horizontal cut through the fascia lata inferior to the inguinal ligament from the superior margin of the saphenous

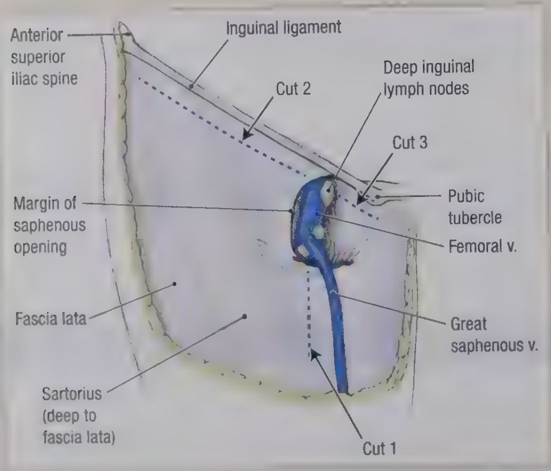

Anterior superior iliac spine
Inguinal ligament
Cut 2
Deep inguinal lymph nodes
Cut 3
Pubic tubercle
Margin of saphenous opening
Femoral v.
Fascia lata
Great saphenous v.
Sartorius (deep to fascia lata)
Cut 1

FIGURE 6.7 ● Opening the fascia lata over the right femoral triangle. Anterior view.

opening to a point directly inferior to the **pubic tubercle** (Cut 3).

12. Use blunt dissection to elevate and separate the fascia lata from the underlying deeper structures.

## Femoral Triangle

ATLAS 6.17, 6.18; VIDEO 6.2.2

1. Refer to FIGURE 6.8.
2. Reflect the flaps of fascia lata medially and laterally to open the superficial boundary or "roof" of the **femoral triangle**.
3. Use scissors to remove the flaps of fascia lata overlying the femoral triangle and the anterior surface of the proximal thigh.
4. Observe that the femoral triangle is oriented in such a way that the base of the triangle (**superior border**) is formed by the **inguinal ligament**, and its apex is directed inferiorly at the point where the sartorius crosses the adductor longus.
5. Identify and clean the proximal portion of the **sartorius muscle**, which forms the **lateral boundary of the femoral triangle**.
6. Identify and clean the proximal portion of the **adductor longus muscle**, which forms the **medial boundary of the femoral triangle**.
7. From lateral to medial, the major **contents of the femoral triangle** are the **femoral nerve**, the **femoral artery**, and the **femoral vein**. *Note that the femoral triangle also contains fat, fascia, lymphatics, branches of the femoral artery and nerve, and tributaries of the vein including the great saphenous vein.*

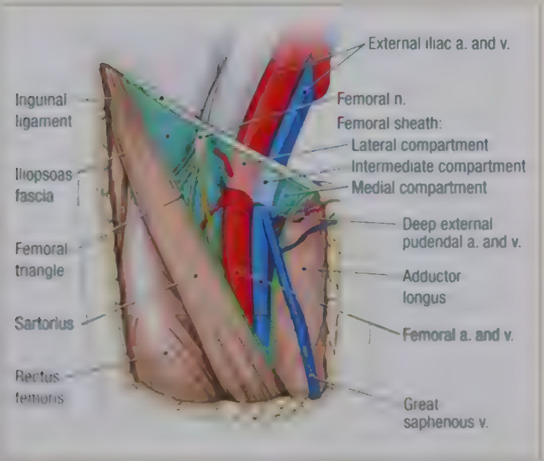


FIGURE 6.8 ● Boundaries and contents of the right femoral triangle. Anterior view.

CLINICAL CORRELATION

### Femoral Triangle and Femoral Hernia

ATLAS 6.18

Within the femoral triangle, the pulse of the femoral artery can be palpated about 3 cm inferior to the midpoint of the inguinal ligament. The femoral vein lies immediately medial to the femoral artery and lateral to the space of the femoral ring. A catheter introduced into the femoral artery can be advanced superiorly into the aorta and its branches. A catheter introduced into the femoral vein can be advanced superiorly into the inferior vena cava and the right atrium of the heart.

The femoral ring is a site of potential herniation. A femoral hernia is a protrusion of abdominal viscera through the femoral ring into the femoral canal. A femoral hernia may become strangulated due to the inflexibility of the surrounding structures.

8. Retract the femoral artery, vein, and nerve and identify the two muscles forming the **floor of the femoral triangle**, the **iliopsoas muscle** laterally and the **pectineus muscle** medially. *Note that the iliacus and psoas major muscles collectively are named the* ***iliopsoas muscle*** *inferior to the inguinal ligament.*
9. Identify the **femoral sheath**, an extension of transversalis fascia that continues into the thigh and surrounds the femoral vessels. *Note that the femoral sheath is divided into three compartments.*
10. Identify the femoral artery in the **lateral compartment** and the femoral vein in the **intermediate compartment** of the femoral sheath.
11. The medial compartment of the femoral sheath is also called the **femoral canal**, and its proximal opening into the abdominal cavity is called the **femoral ring**. *Note that the femoral canal contains lymphatic vessels and lymph nodes and is more readily seen from the abdominal side of the inguinal ligament.*
12. Observe that the lateral-to-medial arrangement of structures that pass under the inguinal ligament (including the contents of the femoral sheath) can be identified by use of the mnemonic device **NAVL** (pronounced navel): femoral **N**erve, femoral **A**rtery, femoral **V**ein, **L**ymphatics.
13. Identify the **femoral nerve**, which lies on the floor of the femoral triangle, external to the femoral sheath, lateral to the femoral artery.
14. Follow the femoral nerve inferiorly and observe that it divides into numerous branches. *Note that the femoral nerve innervates the anterior thigh muscles and the skin of the anterior thigh.*
15. Verify that the **anterior cutaneous branches of the femoral nerve** enter the superficial fascia by penetrating the fascia lata along the anterior surface of the sartorius muscle.

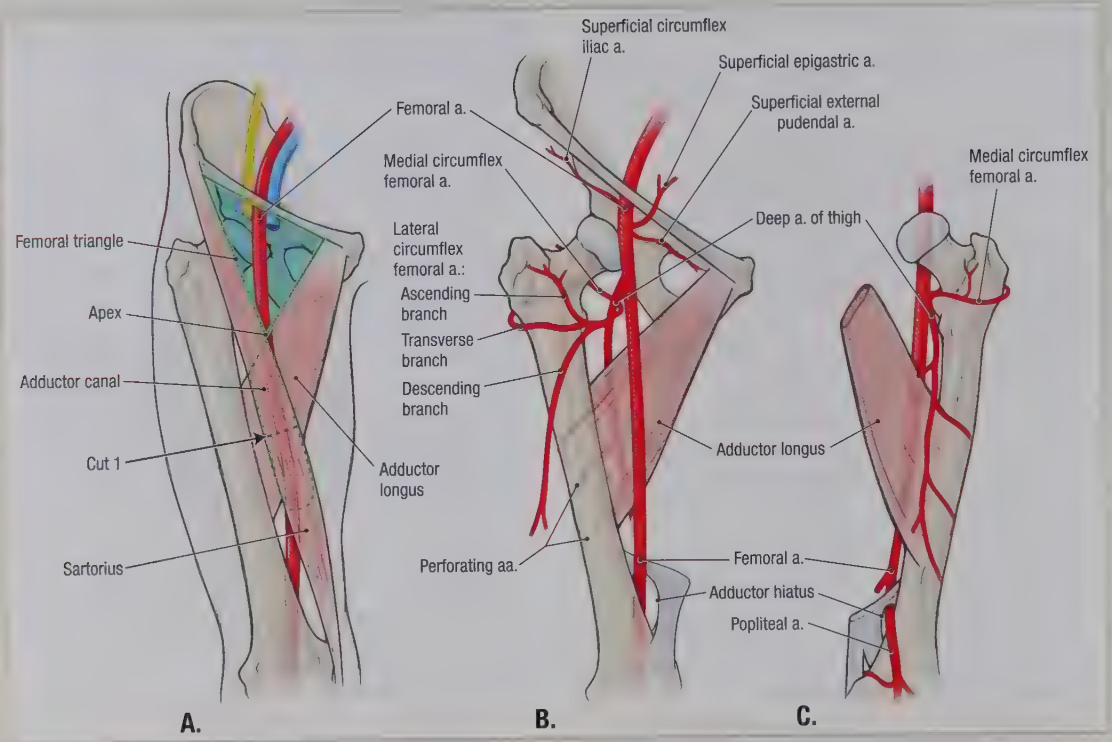

Femoral triangle
Apex
Adductor canal
Cut 1
Sartorius
Femoral a.
Adductor longus
A.
Superficial circumflex iliac a.
Superficial epigastric a.
Superficial external pudendal a.
Medial circumflex femoral a.
Lateral circumflex femoral a.:
Ascending branch
Transverse branch
Descending branch
Deep a. of thigh
Adductor longus
Perforating aa.
Femoral a.
Adductor hiatus
Popliteal a.
B.
Medial circumflex femoral a.
C.

FIGURE 6.9 ■ **A.** Femoral artery path through the femoral triangle and adductor canal. Anterior view. **B.** Branches of the femoral artery. Anterior view. **C.** Deep artery of the thigh and medial circumflex femoral artery path. Posterior view.

16. Use blunt dissection to clean the **femoral artery** and **femoral vein** within the femoral triangle.
17. Refer to FIGURE 6.9A.
18. Observe that inferior to the apex of the femoral triangle, the **femoral artery and vein** course between the sartorius muscle and the adductor longus muscle and enter a space known as the **adductor canal**. Do not yet make an effort to dissect the adductor canal because this will be done later.
19. Refer to FIGURE 6.9B.
20. Inferior to the inguinal ligament, identify and clean the **superficial epigastric artery** coursing superiorly and superficially from the femoral artery.
21. Coursing more deeply from the femoral artery, identify and clean the laterally oriented **superficial circumflex iliac artery** and the medially oriented **superficial external pudendal artery**.
22. Gently retract the femoral artery medially and identify the **deep artery (profunda femoris) of the thigh**. Observe that the deep artery of the thigh courses parallel to the femoral artery but *posterior* to the adductor longus muscle. *Note that the deep artery of the thigh supplies the medial and posterior compartments of the thigh.*
23. Identify and clean the **lateral circumflex femoral artery** arising from the deep artery of the thigh. *Note that the lateral circumflex femoral artery usually arises from the deep artery of the thigh very close to the femoral artery but may arise directly from the femoral artery.*
24. Follow the lateral circumflex femoral artery laterally, deep to the superior end of the rectus femoris muscle and observe that it supplies the muscles and soft tissues of the lateral part of the thigh by three main branches: ascending, transverse, and descending.
25. Identify the **ascending** branch, which passes superiorly deep to the tensor of the fascia lata muscle to anastomose with the superior gluteal artery.
26. Identify the **transverse** branch, which passes deep to the rectus femoris muscle to anastomose with the medial circumflex femoral artery.
27. Identify the **descending branch**, which also passes deep to the rectus femoris muscle and then courses inferiorly on the anterior surface of the vastus intermedius muscle to anastomose with the genicular arteries at the knee.
28. Refer to FIGURE 6.9C.
29. Identify the **medial circumflex femoral artery** arising from the deep artery of the thigh. *Note that the*

*medial circumflex femoral artery typically arises from the deep artery of the thigh close to the femoral artery but may arise directly from the femoral artery.*

30. Follow the medial circumflex femoral artery directly posteriorly between the pectineus and iliopsoas muscles. *Note that in addition to supplying the soft tissues of the region, the medial circumflex femoral artery provides an important blood supply to the neck of the femur.*
31. Make an effort to clean the surface of the iliopsoas muscle and the pectineus muscle that lie posterior to the vessels.
32. Review the attachments and actions of the iliopsoas and pectineus muscles (see **TABLE 6.1**).

## Adductor Canal and Sartorius Muscle

ATLAS 6.19, 6.25; VIDEO 6.2.3

1. Refer to FIGURE 6.9.
2. Identify the **adductor canal,** a fascial compartment located deep to the sartorius muscle.
3. Observe that the adductor canal begins at the **apex of the femoral triangle** and ends at the **adductor hiatus** just above the knee. *Note that the adductor canal contains the femoral artery and vein, which pass through the adductor hiatus to reach the popliteal fossa, and two branches of the femoral nerve.*
4. Use scissors to cut the fascia lata along the superficial surface of the sartorius muscle from the ASIS to the medial epicondyle of the femur.
5. Use blunt dissection to separate the **sartorius muscle** from the deep fascia that encloses it and observe that the sartorius muscle crosses both the hip and the knee joints.
6. Retract the sartorius muscle laterally so its superior and inferior attachments can be defined and its blood and nerve supplies can be identified.
7. Review the attachments and actions of the sartorius muscle (see **TABLE 6.1**).
8. Pull the sartorius laterally and observe a sheath of dense connective tissue encloses the femoral vessels within the **adductor canal.**
9. Use scissors to open the adductor canal along its anterior aspect and examine the relationship of the femoral vessels. Observe that the **femoral vein** now lies posterior to the **femoral artery**. Recall that in the femoral triangle, they were side by side with the vein positioned medial to the artery.
10. Use blunt dissection to follow the femoral artery distally through the **adductor hiatus**, where its name changes to **popliteal artery**.
11. Within the adductor canal, identify the **nerve to vastus medialis** and the **saphenous nerve**. *Note that the nerve to vastus medialis is the motor nerve to the vastus medialis muscle and the saphenous nerve is a cutaneous nerve that innervates the skin on the medial side of the leg, ankle, and foot.*
12. On one side of the cadaver, cut the sartorius muscle midway down its length and reflect the component parts of the muscle superiorly and inferiorly (**Cut 1**).

## Quadriceps Femoris Muscle

ATLAS 6.21, 6.22; VIDEO 6.2.4

1. Refer to FIGURE 6.10.
2. Use scissors to make a vertical cut through the fascia lata beginning at the apex of the femoral triangle and ending at the superior border of the patella.

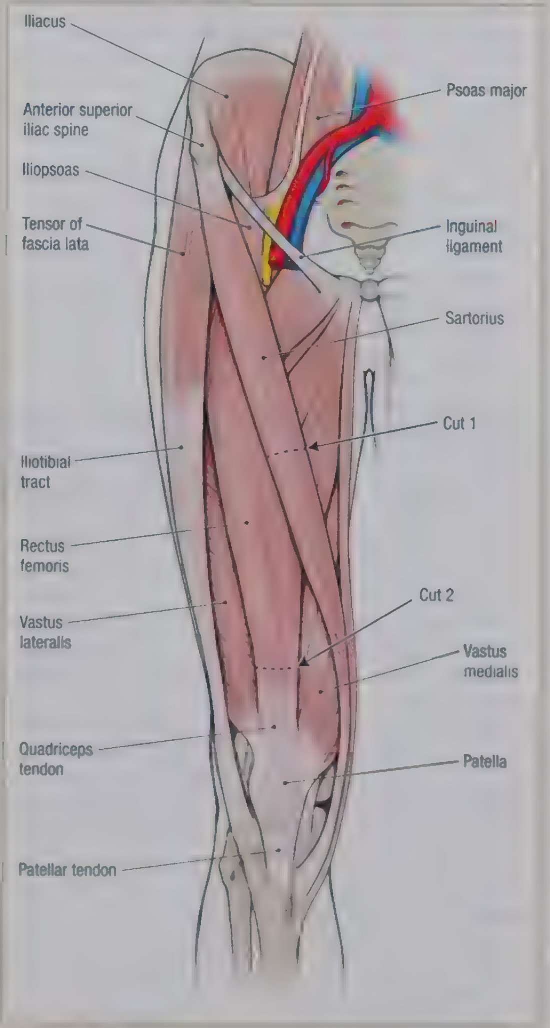


FIGURE 6.10 ● Anterior compartment of the right thigh. Anterior view.

3. Make a transverse incision in the fascia lata above the patella extending from the medial femoral epicondyle to the lateral femoral epicondyle.
4. Use blunt dissection to open the fascia lata widely and follow the inner surface laterally to verify that it is attached to the **lateral intermuscular septum**. *Note that the lateral intermuscular septum is attached to the* ***linea aspera*** *on the posterior aspect of the femur.*
5. Identify the **quadriceps femoris muscle** (the rectus femoris, vastus lateralis, vastus intermedius, and vastus medialis) and observe that it occupies most of the anterior compartment of the thigh.
6. Observe that the tendons of all four quadriceps muscles unite to form the **quadriceps femoris tendon** superior to the patella.
7. Inferior to the patella, identify the **patellar (tendon) ligament** attaching to the tibial tuberosity. *Note that the patella is a sesamoid bone, meaning it formed within the tendon, therefore the inferior attachment of the quadriceps femoris muscle is ultimately on the tibial tuberosity.*
8. Identify and clean the surface of the **rectus femoris muscle** in the midline of the anterior thigh and observe that it crosses both the hip and knee joints.
9. Identify and clean the surface of the **vastus lateralis muscle** on the lateral side of the anterior thigh.
10. Identify and clean the surface of the **vastus medialis muscle** on the medial side of the anterior thigh.
11. Retract the rectus femoris muscle and identify the **vastus intermedius muscle**, which lies deep to the rectus femoris, between the vastus lateralis and vastus medialis muscles.
12. On one side of the cadaver, transect the rectus femoris (**Cut 2**) and reflect its component parts superiorly and inferiorly to expose the deep muscle.
13. Review the attachments and actions of the component parts of the quadriceps muscle (see **TABLE 6.1**).
14. Refer to FIGURE 6.11.
15. Observe the descending branch of the lateral circumflex femoral artery can be seen on the anterior surface of the vastus intermedius muscle deep to the rectus femoris muscle.
16. Identify the **motor branches of the femoral nerve** to the anterior thigh muscles between the rectus femoris muscle and the three vastus muscles. *Note that the femoral nerve innervates the sartorius muscle and the pectineus muscle in addition to innervating the quadriceps femoris muscle.*

## Tensor of Fascia Lata Muscle

ATLAS 6.21A, 6.26; VIDEO 6.2.5

1. Refer back to FIGURE 6.10.
2. On the lateral aspect of the thigh, identify the **IT band**, a thickening of the fascia lata.

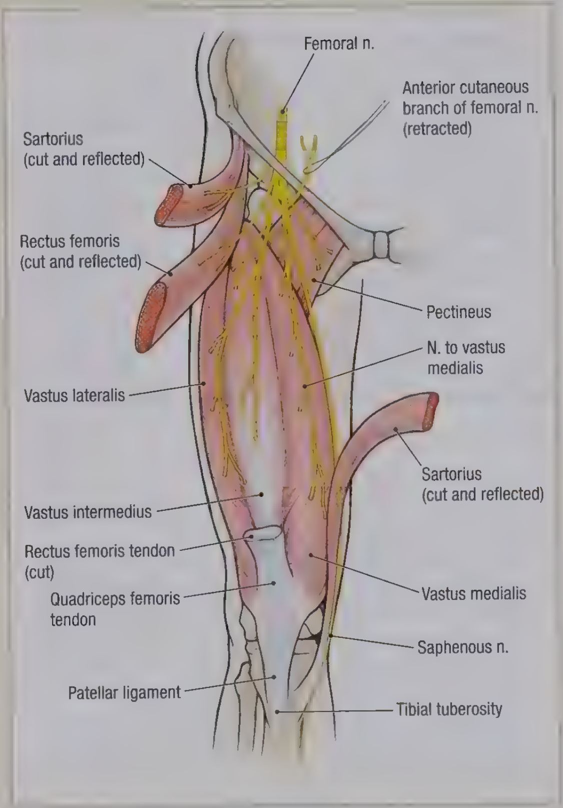

Femoral n.
Anterior cutaneous branch of femoral n. (retracted)
Sartorius (cut and reflected)
Rectus femoris (cut and reflected)
Pectineus
N. to vastus medialis
Vastus lateralis
Sartorius (cut and reflected)
Vastus intermedius
Rectus femoris tendon (cut)
Vastus medialis
Quadriceps femoris tendon
Saphenous n.
Patellar ligament
Tibial tuberosity

FIGURE 6.11 ■ Branches of the right femoral nerve. Anterior view.

3. Elevate the remaining fascia lata from the anterior aspect of the thigh and cut through the fascia along a line from the ASIS proximally to a point just lateral to the lateral femoral condyle distally. Leave the majority of the fascia undisturbed along the lateral aspect of the thigh and just define the anterior edge of the iliotibial tract at this time.
4. Within the iliotibial tract proximally, identify the **tensor of the fascia lata (tensor fasciae latae, TFL) muscle.** *Note that the TFL is often categorized with the gluteal muscles despite its location on the anterior aspect of the hip due to its motor innervation by the superior gluteal nerve.*
5. Observe that the TFL is enclosed within the fascia lata inferior to the ASIS and connects to the iliotibial tract distally. The iliotibial tract serves to strengthen the lateral aspect of the knee and is an insertion point for both the TFL and the gluteus maximus muscles.
6. Make a short incision through the fascia lata paralleling the anterior aspect of the TFL.

7. Use blunt dissection to separate the medial and lateral surfaces of the TFL away from the fascia lata.
8. Remove a small portion of the fascia lata to expose the anterior and lateral surfaces of the TFL but do not disrupt the iliotibial tract or the attachments of the muscle.
9. Review the attachments and actions of the TFL (see **TABLE 6.1**).

**CLINICAL CORRELATION**

### Patellar Tendon (Quadriceps) Reflex

ATLAS 6.7, 6.45

Tapping the patellar tendon stimulates the patellar reflex (quadriceps reflex; knee jerk) and tests the function of the femoral nerve and spinal cord segments L2–L4. Tapping the tendon activates muscle spindles in the quadriceps femoris muscle sending afferent impulses in the femoral nerve to spinal cord segments L2–L4. Within the spinal cord an interneuron rapidly sends the incoming sensory information from the posterior horn to the motor cell bodies in the anterior horn of gray matter. Efferent impulses are then carried by the femoral nerve to the quadriceps femoris muscle, resulting in a brief muscular contraction under normal function.

## Dissection Follow-up

1. Use the dissected specimen to review the boundaries and contents of the femoral triangle.
2. Review the origin and course of the femoral artery and its branches in the thigh.
3. Use the dissected specimen to review the attachments and actions of the muscles of the anterior compartment of the thigh as shown in **TABLE 6.1**.
4. Review the pattern of motor innervation to the muscles in the anterior compartment of the thigh, noting the muscles receiving dual innervation.
5. Replace the muscles of the anterior compartment of the thigh back to anatomical position.

**TABLE 6.1 | Muscles of the Anterior Thigh**

| ANTERIOR THIGH | | | | |
|---|---|---|---|---|
| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
| Pectineus | Pecten pubis and superior ramus of the pubis | Pectineal line of the femur | Adducts and flexes the thigh | Femoral n. and obturator n. |
| Iliopsoas | Iliac fossa (iliacus) and TP and bodies of vertebrae T12–L5 (psoas major) | Lesser trochanter of the femur | Flexes the thigh | Femoral n. |
| Sartorius | Anterior superior iliac spine | Medial surface of the proximal tibia | Flexes and laterally rotates the thigh; flexes and medially rotates the leg | |
| Tensor fasciae lata | Anterior superior iliac spine | Iliotibial tract | Abducts, medially rotates, and flexes the thigh | Superior gluteal n. |
| QUADRICEPS | | | | |
| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
| Rectus femoris | Anterior inferior iliac spine | Tibial tuberosity | Flexes the thigh and extends the leg | Femoral n. |
| Vastus medialis | Medial lip of the linea aspera and intertrochanteric line | | Extends the leg | |
| Vastus lateralis | Lateral lip of the linea aspera and greater trochanter | | | |
| Vastus intermedius | Anterior and lateral surfaces of the femur | | | |

Abbreviations: L, lumbar vertebrae; n., nerve; T, thoracic vertebrae; TP, transverse process.

# MEDIAL COMPARTMENT OF THE THIGH

## Dissection Overview

The medial compartment of the thigh contains six muscles: gracilis, adductor longus, adductor brevis, pectineus, adductor magnus, and obturator externus. The muscles of the medial compartment of the thigh are innervated by the obturator nerve. The shared function of the medial compartment of the thigh is to adduct the thigh, thus this group of muscles is also known as the adductor group of thigh muscles.

The order of dissection will be as follows: The fascia lata will be removed from the medial thigh. The gracilis muscle will be studied. The adductor muscles will be separated from each other by following the medial circumflex femoral artery, the deep artery of the thigh, and the branches of the obturator nerve.

## Dissection Instructions

### Medial Compartment of the Thigh

ATLAS 6.24, 6.25; VIDEO 6.3.1

1. Refer to FIGURE 6.12.
2. On the medial aspect of the thigh, use blunt dissection to separate the fascia lata from the muscles of the medial compartment beginning at the medial border of the femoral triangle and working medially.
3. Elevate the fascia lata on the medial aspect of the thigh and identify the **gracilis muscle**, the most medial muscle of the thigh.
4. Use scissors to cut the fascia lata from its attachments to the pelvis superiorly and along the medial intermuscular septum, paying attention not to remove the gracilis muscle in the process.
5. Remove the cut portion of the fascia lata and place it in the tissue container.
6. Use blunt dissection to define the borders of the gracilis muscle and observe that it crosses both the hip and knee joints and thus will assist movement at both joints.
7. Review the attachments, actions, and innervation of the gracilis muscle (see **TABLE 6.2**).
8. Lateral to the gracilis, identify the **adductor longus muscle** and **pectineus muscle**. Recall that the pectineus muscle forms part of the floor of the femoral triangle.
9. Verify through palpation that the superior attachments of the gracilis, pectineus, and adductor longus muscles are all on the pubic bone.
10. Within the femoral triangle, identify the **deep artery of the thigh** where it branches from the femoral artery.
11. Follow the deep artery of the thigh inferiorly and observe that it passes anterior to the pectineus and posterior to the adductor longus muscle.
12. Use blunt dissection to define the borders of the pectineus and adductor longus muscles while preserving the deep artery of the thigh.
13. Review the attachments, actions, and innervation of the adductor longus and pectineus muscles (see **TABLE 6.2**).
14. Gently pull the adductor longus muscle medially and the pectineus muscle laterally and identify the more deeply located **adductor brevis muscle**.
15. Follow the deep artery of the thigh posterior to the adductor longus muscle and observe that it courses inferiorly between the adductor longus muscle and the adductor brevis muscle.

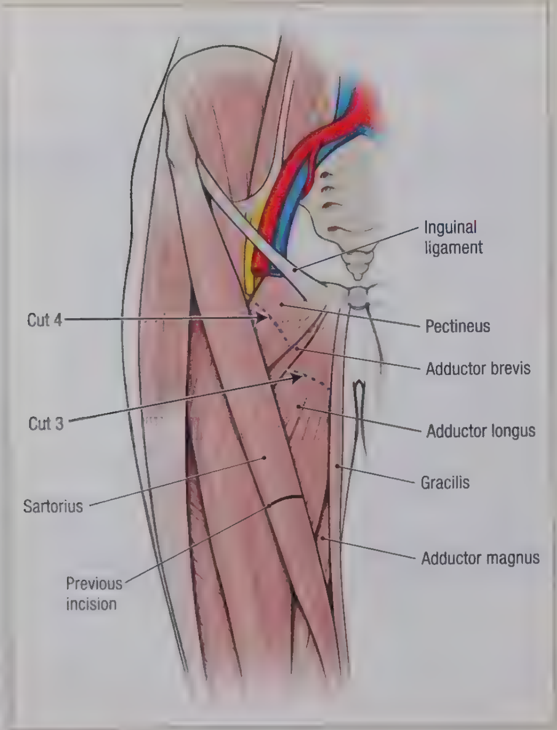


FIGURE 6.12 ● Contents of the medial compartment of the right thigh. Anterior view.

***Dissection Note:*** Use the deep artery of the thigh as a landmark to separate the adductor longus muscle from the adductor brevis muscle.

16. On one side of the cadaver, use blunt dissection to gently elevate the adductor longus muscle.
17. Transect the adductor longus muscle 5 cm inferior to its superior attachment (**Cut 3**) and reflect the cut portions superiorly and inferiorly to expose the **adductor brevis muscle**.
18. On the same side of the cadaver where the adductor longus was transected, use blunt dissection to carefully elevate the pectineus muscle and transect it near the path of the cut through the adductor longus (**Cut 4**).
19. Clean the deep artery of the thigh and identify one or two **perforating arteries**. *Note that the perforating arteries penetrate the adductor brevis and adductor magnus muscles, encircle the femur, and supply the muscles of the posterior compartment of the thigh.*
20. Refer to FIGURE 6.13.

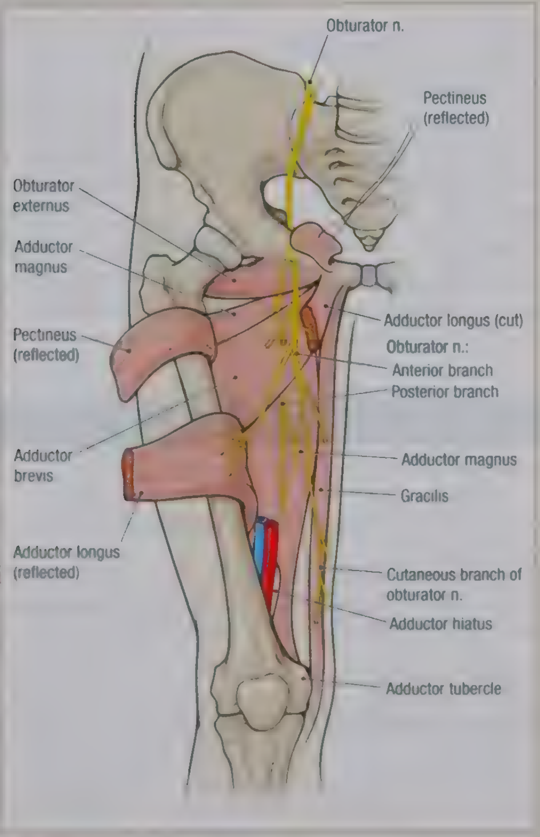


FIGURE 6.13 ■ Branches of the right obturator nerve. Anterior view.

21. Identify the **obturator nerve** deep to the cut adductor longus and pectineus muscles.
22. Observe that the obturator nerve splits into anterior and posterior branches in the medial compartment of the thigh around the adductor brevis.
23. On the anterior surface of the adductor brevis muscle, identify the **anterior branch of the obturator nerve**.
24. Follow the anterior branch of the obturator nerve superiorly deep to the pectineus muscle and use the nerve as a landmark to separate the pectineus muscle from the adductor brevis muscle. *Note that the superior border of the adductor brevis muscle is deep to the pectineus muscle.*
25. Use blunt dissection to clean the adductor brevis, paying attention not to damage the anterior branches of the obturator nerve.
26. Gently elevate the adductor brevis muscle and identify the **adductor magnus muscle** deep to the adductor longus muscle and medial to the gracilis muscle. *Note that the adductor magnus muscle has both a hamstring (ischiocondylar) portion and an adductor portion and thus shares actions and innervations with both groups of muscles.*
27. Identify the **posterior branch of the obturator nerve** where it lies between the adductor brevis muscle and the adductor magnus muscle.
28. Use blunt dissection to follow the posterior branch of the obturator nerve superiorly and use the nerve as a landmark to separate the adductor brevis muscle from the adductor magnus muscle.
29. Review the attachments, actions, and innervation of the adductor brevis and adductor magnus muscles (see **TABLE 6.2**).
30. Separate the pectineus and iliopsoas muscles to identify the **obturator externus muscle**. *Note to clearly visualize the obturator externus the pectineus and iliopsoas need to be transected and reflected, a step performed later with the dissection of the hip joint.*
31. Review the attachments, actions, and innervation of the obturator externus muscle.
32. Trace the tendon of the hamstring (ischiocondylar) part of the adductor magnus muscle inferiorly to its attachment on the **adductor tubercle**.
33. On the lateral side of the tendon, observe the **adductor hiatus**, an opening in the adductor magnus muscle.
34. Observe that the femoral artery and vein pass from the anterior compartment of the thigh into the posterior compartment of the thigh by passing through the adductor hiatus. *Note that the adductor hiatus is the landmark where the femoral artery and vein change names to popliteal artery and vein.*

## Dissection Follow-up

1. Use the dissected specimen to review the attachments and actions of each muscle dissected as shown in **TABLE 6.2**.
2. Trace the deep artery of the thigh from its origin to its termination as the fourth perforating artery.
3. Trace the medial circumflex femoral artery from its origin to where it passes between the iliopsoas and pectineus muscles.
4. Trace the course of the anterior and posterior branches of the obturator nerve superiorly as far as the superior border of the adductor brevis muscle.
5. Recall the pattern of motor innervation to the muscles of the medial compartment of the thigh, noting the muscles that receive dual innervation.
6. Replace the medial thigh muscles in their correct anatomical positions.

**TABLE 6.2 Muscles of the Medial Thigh (Adductors)**

MEDIAL THIGH

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Gracilis | Body of pubis and inferior pubic ramus | Superior part of medial surface of tibia | Adducts the thigh; flexes and internally rotates the leg | Obturator n. |
| Pectineus | Superior pubic ramus | Pectineal line | Adducts the thigh | Obturator n. and femoral n. |
| Adductor longus | Body of pubis inferior to pubic crest | Middle third of linea aspera | | Obturator n. |
| Adductor brevis | Body of pubis and inferior pubic ramus | Pectineal line and proximal part of linea aspera | | |
| Adductor magnus | Ischiopubic ramus and ischial tuberosity | Gluteal tuberosity, linea aspera, medial supracondylar line (adductor part); adductor tubercle of the femur (hamstring part) | Adducts and extends the thigh | Obturator n. (adductor part); tibial division of the sciatic n. (hamstring part) |
| Obturator externus | External margins of obturator foramen and obturator membrane (medial attachment) | Trochanteric fossa of femur (lateral attachment) | Laterally rotates the thigh | Obturator n. |

Abbreviation: n., nerve.

# GLUTEAL REGION

## Dissection Overview

The gluteal region lies on the posterior aspect of the pelvis and is the most superior part of the lower limb. The gluteal region contains muscles that extend, abduct, and laterally rotate the thigh.

The order of dissection will be as follows: The superficial fascia will be removed from the gluteal region. The borders of the gluteus maximus muscle will be defined, and it will be reflected laterally to expose the muscles that lie deep to it. Muscles that lie deep to the gluteus maximus muscle will be studied. Arteries and nerves in the region will be studied.

### Skeletal Anatomy

Refer to an articulated skeleton or disarticulated lower limb skeleton to identify the following skeletal features.

#### *Posterior Hip*

ATLAS 1.20B, 6.27C

1. Refer to FIGURE 6.14.
2. Identify the **iliac crest** on the superior aspect of the **ilium**.

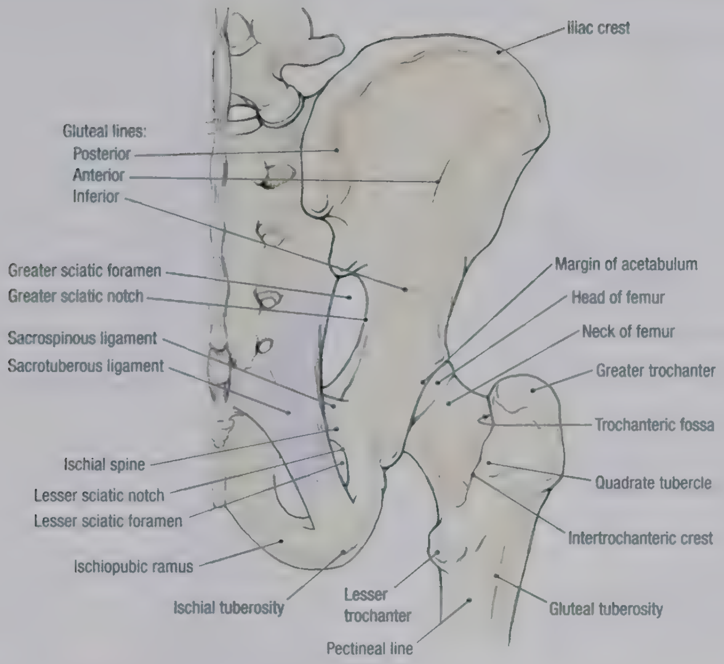

Iliac crest
Gluteal lines:
Posterior
Anterior
Inferior
Greater sciatic foramen
Greater sciatic notch
Sacrospinous ligament
Sacrotuberous ligament
Margin of acetabulum
Head of femur
Neck of femur
Greater trochanter
Trochanteric fossa
Quadrate tubercle
Intertrochanteric crest
Ischial spine
Lesser sciatic notch
Lesser sciatic foramen
Ischiopubic ramus
Ischial tuberosity
Lesser trochanter
Pectineal line
Gluteal tuberosity

FIGURE 6.14 ● Skeleton of the right gluteal region. Posterior view.

3. On the lateral (external) surface of the ilium, identify the **gluteal lines (posterior, anterior, inferior)**.
4. On the posterior aspect of the ilium, identify the **greater sciatic notch**. Observe that the greater sciatic notch is located superior to the **ischial spine** and is part of the ilium, whereas the **lesser sciatic notch** is located inferior to the ischial spine and is part of the **ischium**.
5. On an articulated pelvis, identify the **sacrospinous ligament** connecting from the sacrum to the ischial spine. Observe that the greater sciatic notch forms part of the margin of the **greater sciatic foramen** along with the sacrospinous ligament.
6. On an articulated pelvis, identify the **sacrotuberous ligament** connecting from the sacrum to the **ischial tuberosity**. Observe that the lesser sciatic notch forms part of the margin of the **lesser sciatic foramen** along with the sacrotuberous and sacrospinous ligaments.

## *Proximal Posterior Femur*

ATLAS 6.27C

1. Refer to FIGURE 6.14.
2. On the proximal femur, identify the **greater trochanter** posteriorly and laterally.
3. Identify the depression of the **trochanteric fossa** on the medial aspect of the greater trochanter posteriorly.
4. On the posterior aspect of the proximal femur, identify the **intertrochanteric crest** between the greater trochanter and **lesser trochanter**.
5. Approximately midway down the length of the intertrochanteric crest, identify the **quadrate tubercle**.
6. Identify the roughened area of the **gluteal tuberosity** on the posterior aspect of the proximal femur inferior to the intertrochanteric crest.

## Dissection Instructions

### Gluteus Maximus Muscle

ATLAS 6.28B, 6.29C; VIDEO 6.4.1

1. Refer to FIGURE 6.15.
2. Place the cadaver in the prone position.
3. Identify the **gluteus maximus muscle** and observe that it attaches to the iliotibial tract inferiorly, and through it, the lateral condyle of the tibia. *Note that because the gluteus maximus attaches to both the gluteal tuberosity of the femur directly and the fascia lata, which connects to the lateral intermuscular septum, it effectively attaches to the entire length of the femur and therefore acts as a powerful extensor of the thigh.*
4. Identify and clean the entire length of the inferior border of the gluteus maximus muscle beginning medially near its attachment on the sacrum and coccyx.
5. Along the inferior border of the gluteus maximus muscle, identify the inferior cluneal nerves if not done previously but do not spend considerable time doing so.
6. Use blunt dissection to define the superior border of the gluteus maximus muscle.
7. Remove the fascia lata from the posterior surface of the gluteus maximus muscle and clean the entire expanse of the muscle.
8. Observe that the fascia lata is relatively thin over the surface of the gluteus maximus muscle, but superior to the muscle, it becomes thicker and forms the **gluteal aponeurosis**. Observe that the gluteal aponeurosis spans from the superior border of the gluteus maximus muscle up to the iliac crest and overlies the gluteus medius muscle.
9. Use blunt dissection to separate the gluteus maximus muscle from the gluteal aponeurosis along the superior border of the muscle (**Cut 1**). *Note that the aponeurosis may be strongly connected to fascia lata, and it may be necessary to use scissors to cut through the connection.*
10. Near the inferior border of the gluteus maximus, palpate the sacrotuberous ligament through the muscular belly of the gluteus maximus and observe its orientation.
11. Detach the gluteus maximus from its medial attachment beginning superiorly at the superior border of the muscle and reflect the muscle from its attachment to the ilium, sacrum, and sacrotuberous ligament (**Cut 2**). *Note that the gluteus maximus muscle is often tightly adhered along the length of the sacrotuberous ligament, and care must be taken not to cut through the ligament while reflecting the muscle laterally.*
12. While reflecting the gluteus maximus muscle, palpate the **inferior gluteal artery**, **vein**, and **nerve**, which are located near the center of the muscle. *Note that the inferior gluteal nerve is the only nerve supply to the gluteus maximus muscle, but the muscle receives blood from both the superior gluteal artery and the inferior gluteal artery.*
13. Use scissors to cut the inferior gluteal vessels and nerve near the muscle belly of the gluteus maximus.
14. Use blunt dissection to loosen the gluteus maximus muscle from the remaining deeper structures and reflect it laterally so it is only attached along its lateral attachments to the iliotibial tract and gluteal tuberosity.
15. Review the attachments and actions of the gluteus maximus muscle (see **TABLE 6.3**).

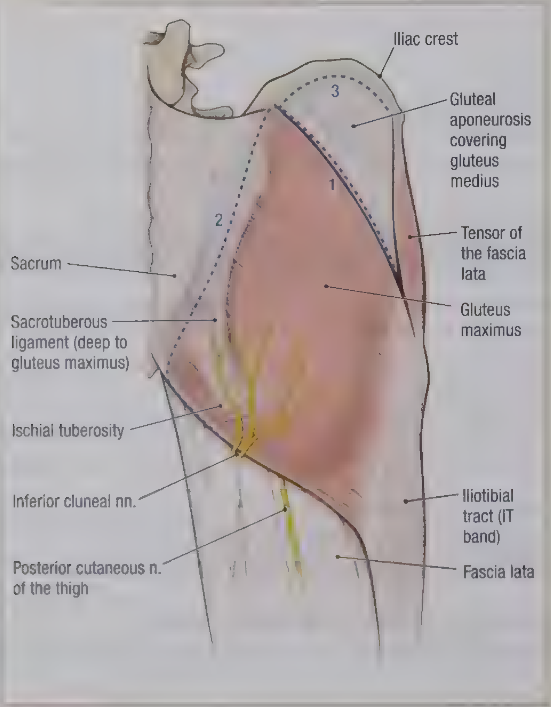

Iliac crest
3
Gluteal aponeurosis covering gluteus medius
1
2
Tensor of the fascia lata
Sacrum
Gluteus maximus
Sacrotuberous ligament (deep to gluteus maximus)
Ischial tuberosity
Inferior cluneal nn.
Iliotibial tract (IT band)
Posterior cutaneous n. of the thigh
Fascia lata

FIGURE 6.15 ■ Superficial dissection of the right gluteal region. Posterior view.

### Gluteus Medius and Minimus Muscles

ATLAS 6.28C, 6.28D, 6.29C, 6.29D, 6.29E; VIDEO 6.4.2

1. Refer to FIGURE 6.15.
2. Use a scalpel to cut the gluteal aponeurosis along the iliac crest and use skinning motions to remove the gluteal aponeurosis to expose the gluteus medius muscle (**Cut 3**). *Note that the aponeurosis is firmly attached to the gluteus medius muscle and that it serves as an attachment for the muscle.*
3. Identify the **gluteus medius muscle** and use blunt dissection to define its borders.

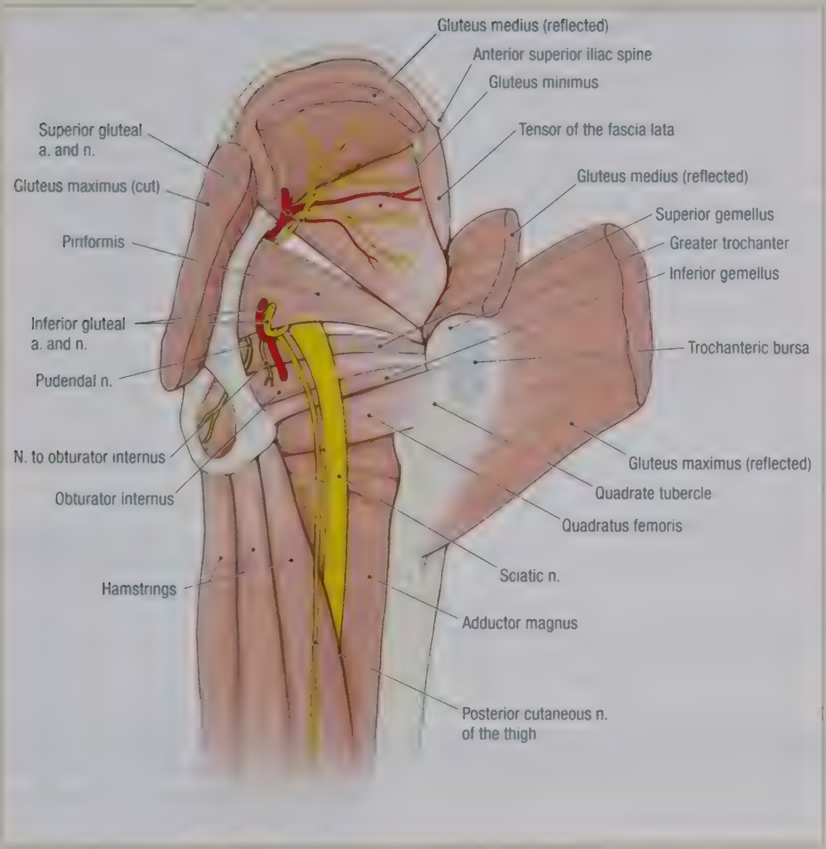

Gluteus medius (reflected)
Anterior superior iliac spine
Gluteus minimus
Superior gluteal a. and n.
Tensor of the fascia lata
Gluteus maximus (cut)
Gluteus medius (reflected)
Superior gemellus
Piriformis
Greater trochanter
Inferior gemellus
Inferior gluteal a. and n.
Trochanteric bursa
Pudendal n.
N. to obturator internus
Gluteus maximus (reflected)
Obturator internus
Quadrate tubercle
Quadratus femoris
Sciatic n.
Hamstrings
Adductor magnus
Posterior cutaneous n. of the thigh

FIGURE 6.16 ■ Deep dissection of the right gluteal region. Posterior view.

4. Observe that the gluteus medius attaches more superiorly than the gluteus maximus and is visible even with the gluteus maximus in its anatomical location.
5. Review the attachments, actions, and innervation of the gluteus medius muscle (see **TABLE 6.3**).
6. Refer to FIGURE 6.16.
7. Inferior and medial to the gluteus medius muscle, identify the **piriformis muscle** and observe its location approximately in the middle of the gluteal region. *Note that the superior border of the piriformis lies adjacent to the inferior border of the gluteus medius muscle.*
8. Use blunt dissection between the gluteus medius and piriformis muscles to open the interval between them and identify the **superior gluteal vessels**.

***Dissection Note:*** To identify the gluteus minimus muscle, you must reflect the superior part of the gluteus medius muscle.

9. Follow the course of the superior gluteal vessels within the fascial plane between the overlying gluteus medius muscle and the more deeply located gluteus minimus muscle.
10. Use scissors to transect the gluteus medius muscle following the course of the superior gluteal vessels taking care to not disrupt the neurovascular structures.
11. Gently reflect the cut portions of the gluteus medius muscle superiorly and inferiorly, respectively, and identify the **gluteus minimus muscle** and **superior gluteal nerve**. *Note that gluteus minimus muscle cannot be seen without transection of the gluteus medius muscle.*
12. Follow the branches of the superior gluteal nerve to both the gluteus medius and minimus. *Note that branches of the superior gluteal nerve course laterally to innervate the TFL within the fascia lata on the anterior aspect of the hip inferior to the ASIS.*
13. Review the attachments, actions, and innervation of the gluteus minimus and TFL muscles (see **TABLE 6.3**).

### External Rotators of the Hip

ATLAS 6.28D, 6.31; VIDEO 6.4.3

1. Refer to FIGURE 6.16.
2. Use blunt dissection to clean the superior border of the piriformis muscle and observe that the **superior gluteal artery, vein,** and **nerve** exit the pelvic cavity and enter the gluteal region by passing superior to the superior border of the piriformis muscle.
3. Use blunt dissection to clean the inferior border of the piriformis muscle and observe that it lies superior to the cut edge of the **inferior gluteal artery** and **vein**.
4. Identify the **superior gemellus muscle** in the interval inferior to the piriformis muscle. Observe that the piriformis muscle passes through the greater sciatic foramen nearly filling it, whereas the superior gemellus muscle originates from the ischial spine.
5. Inferior to the piriformis muscle, identify the **sciatic nerve**, the largest nerve in the body, consisting of a tibial division and a common fibular division, which may or may not be distinguishable at this point in the dissection.

***Dissection Note:*** Occasionally, the sciatic divisions may emerge from the pelvis separately with the common fibular division passing over the superior border or through the center of the piriformis muscle and the tibial division passing inferior to the piriformis.

6. Make a vertical cut through the fascia lata posterior to the sciatic nerve and follow the sciatic nerve inferiorly for 6 or 7 cm into the thigh.
7. On the medial side of the sciatic nerve, identify the **posterior cutaneous nerve of the thigh**.
8. Follow the posterior cutaneous nerve of the thigh superiorly and observe that it lies lateral to the **inferior gluteal vessels** and **nerve**.
9. Identify the **nerve to obturator internus, internal pudendal artery** and **vein**, and **pudendal nerve** near the medial end of the inferior border of the piriformis muscle.
10. Observe that the pudendal nerve and internal pudendal vessels exit the pelvis by passing through the greater sciatic foramen, between the piriformis and superior gemellus muscles and then enter the perineum by passing through the lesser sciatic foramen. *Note that the pudendal nerve and internal pudendal vessels supply the anal and urogenital triangles.*
11. Identify the tendon of the **obturator internus muscle** inferior to the superior gemellus muscle and superior to the **inferior gemellus muscle**. *Note that the two gemellus muscles attach to the obturator internus tendon and might obscure it.*
12. Use a probe to verify that the obturator internus muscle exits the lesser pelvis by passing through the lesser sciatic foramen.
13. Inferior to the inferior gemellus muscle, identify and clean the **quadratus femoris muscle**.
14. Review the attachments, actions, and innervation of the obturator internus, the superior gemellus, the inferior gemellus, and the quadratus femoris muscles (see **TABLE 6.3**).

**CLINICAL CORRELATION**

#### Intragluteal Injections

ATLAS 6.31

The gluteal region is commonly subdivided into quadrants for delineation of safe regions to use for intramuscular injections. To create the quadrants, a vertical line is drawn down from the highest point of the iliac crest, and a horizontal line is drawn halfway between the high point of the iliac crest and the level of the ischial tuberosity.

Intragluteal injections into the superior lateral quadrant are relatively safe because the superior gluteal nerve and vessels are well branched in this region and rarely is the sciatic nerve in danger of penetration in this location. Injections into the two inferior quadrants of the gluteal region would endanger the sciatic nerve or the nerves and vessels that pass inferior to the piriformis muscle, and injections into the superior medial quadrant could similarly injure the superior gluteal nerve and vessels.

## Dissection Follow-up

1. Review the attachments and innervation of each muscle as shown in **TABLE 6.3**.
2. Study the functions of the muscles in the gluteal region including extension, abduction, and lateral rotation of the thigh.
3. Review the clinical anatomy of the gluteal region and the site where a safe intragluteal injection may be performed.
4. Identify the piriformis muscle and follow it laterally to its attachment on the greater trochanter of the femur.
5. Study the gluteal vessels and their relationship to the piriformis muscle.
6. Review the sacral plexus and its contributions to the sciatic nerve and note that branches of the sacral plexus innervate the muscles of the gluteal region.
7. Replace the muscles of the gluteal region in their correct anatomical positions.

TABLE 6.3 Muscles of the Gluteal Region

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Gluteus maximus | Ilium posterior to posterior gluteal line, dorsal surface of the sacrum and coccyx, and sacrotuberous ligament | Iliotibial tract and gluteal tuberosity | Extends and laterally rotates the thigh | Inferior gluteal n. |
| Gluteus medius | External surface of ilium between anterior and posterior gluteal lines and gluteal fascia | Lateral surface of greater trochanter of the femur | Abducts and medially rotates the thigh | Superior gluteal n. |
| Gluteus minimus | Lateral surface of the ilium between the anterior gluteal and inferior gluteal lines | Anterior surface of greater trochanter of the femur | | |
| Tensor of fasciae lata | Anterior superior iliac spine | Iliotibial tract | Abducts, medially rotates, and flexes the thigh | |
| Piriformis | Anterior surface of the sacrum | Greater trochanter of the femur (lateral) | Laterally rotates the thigh | Anterior rami of S1 and S2 |
| Obturator internus | Internal margin of the obturator foramen and inner surface of the obturator membrane | | | Nerve to obturator internus |
| Superior gemellus | Ischial spine (medial) | Greater trochanter of the femur (lateral) and obturator internus tendon | | |
| Inferior gemellus | Ischial tuberosity (medial) | | | Nerve to quadratus femoris |
| Quadratus femoris | Ischial tuberosity (medial) | Quadrate tubercle (lateral) | | |

Abbreviation: n., nerve; S, sacral vertebrae.

# POSTERIOR COMPARTMENT OF THE THIGH AND POPLITEAL FOSSA

## Dissection Overview

The posterior compartment of the thigh contains the posterior thigh muscles: biceps femoris, semimembranosus, and semitendinosus. The muscles of the posterior group extend the thigh and flex the leg. The posterior thigh muscles are commonly referred to as the "hamstring" muscles, although this excludes the short head of the biceps femoris, which only crosses the knee.

The order of dissection will be as follows: The muscles of the posterior compartment of the thigh will be studied. The course and branches of the sciatic nerve will be studied. The dissection will be extended inferiorly to include the popliteal fossa. The muscular boundaries of the popliteal fossa will be identified, and the contents of the popliteal fossa will be studied.

### Skeletal Anatomy

Refer to an articulated or disarticulated skeleton of the lower limb to identify the following skeletal features.

### *Posterior Hip and Femur*

ATLAS 6.27C

1. Refer to FIGURE 6.17.
2. Identify the roughened area of the **ischial tuberosity** on the inferior aspect of the ischium.
3. On the posterior aspect of the femur, identify the **medial lip** and **lateral lip of the linea aspera**.
4. Follow the medial lip of the linea aspera superiorly to the **pectineal line**, which angles medially toward the **lesser trochanter** of the femur.
5. Follow the linea aspera inferiorly to the point where it widens into the **medial** and **lateral supracondylar lines** to either side of the **popliteal surface**, which in turn transition to the **medial** and **lateral epicondyles**.

6. On the medial epicondyle, identify the **adductor tubercle**.
7. Observe that the medial and lateral epicondyles are located just proximal to the large terminal projections of bone distally on the femur, the **medial** and **lateral condyles**.

### *Proximal Posterior Fibula and Tibia*

ATLAS 6.27C, 6.58B

1. Refer to FIGURE 6.17.
2. On the proximal end of the fibula, identify the **head** of the fibula and observe that it narrows toward the **apex**.
3. Just inferior to the head of the fibula, identify the narrowed region of the **neck** of the fibula.
4. On the proximal tibia, identify the **medial condyle** and the **lateral condyle**.
5. On the proximal tibia posteriorly, identify the obliquely oriented **soleal line**.
6. Observe on an articulated skeleton that the condyles of the femur and tibia align and form the articular surfaces for the weight-bearing portion of the knee joint.
7. Confirm on an articulated skeleton that the fibula does not articulate at the knee.

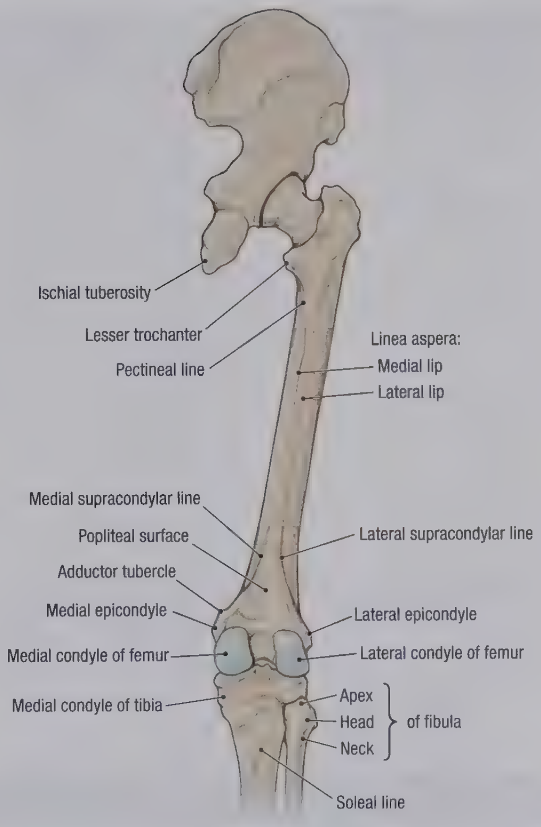

Ischial tuberosity
Lesser trochanter
Pectineal line
Linea aspera:
Medial lip
Lateral lip
Medial supracondylar line
Popliteal surface
Adductor tubercle
Medial epicondyle
Medial condyle of femur
Medial condyle of tibia
Lateral supracondylar line
Lateral epicondyle
Lateral condyle of femur
Apex
Head
Neck
of fibula
Soleal line

FIGURE 6.17 ■ Skeleton of the right hip, thigh, and knee. Posterior view.

## Dissection Instructions

### Posterior Compartment of the Thigh

ATLAS 6.28, 6.30; VIDEO 6.5.1

1. Refer to FIGURE 6.18.
2. Place the cadaver in the prone position.
3. Use scissors to continue the vertical incision made through the fascia lata to expose the **sciatic nerve** and extend the incision from the level of the gluteus maximus muscle to the knee.
4. Spread open the fascia lata medially and laterally and follow the **sciatic nerve** until it branches into the **tibial** and **common fibular nerves**. *Note that prior to the physical point of separation, the portion of the sciatic nerve are typically referred to as the tibial and common fibular divisions because the fibers remain organized along the length of the nerve even prior to branching.*
5. Clean the fascia off the sciatic nerve and observe that it passes deep (anterior) to the **long head of the biceps femoris muscle** and courses inferiorly to the area posterior to the knee, the **popliteal fossa**. *Note that the sciatic nerve may split into the tibial and common fibular divisions in the gluteal region, at any level in the posterior thigh, or in the popliteal fossa.*
6. Locate the **posterior cutaneous nerve of the thigh** in the gluteal region and follow it inferiorly to observe that it sends cutaneous branches through the fascia lata to the posterior surface of the thigh.
7. On the lateral aspect of the posterior thigh, identify and clean the **long head of the biceps femoris muscle**.
8. Retract the long head of the biceps femoris muscle and identify and clean the **short head of the biceps femoris muscle**.
9. Review the attachments and actions of the biceps femoris muscle (see **TABLE 6.4**).

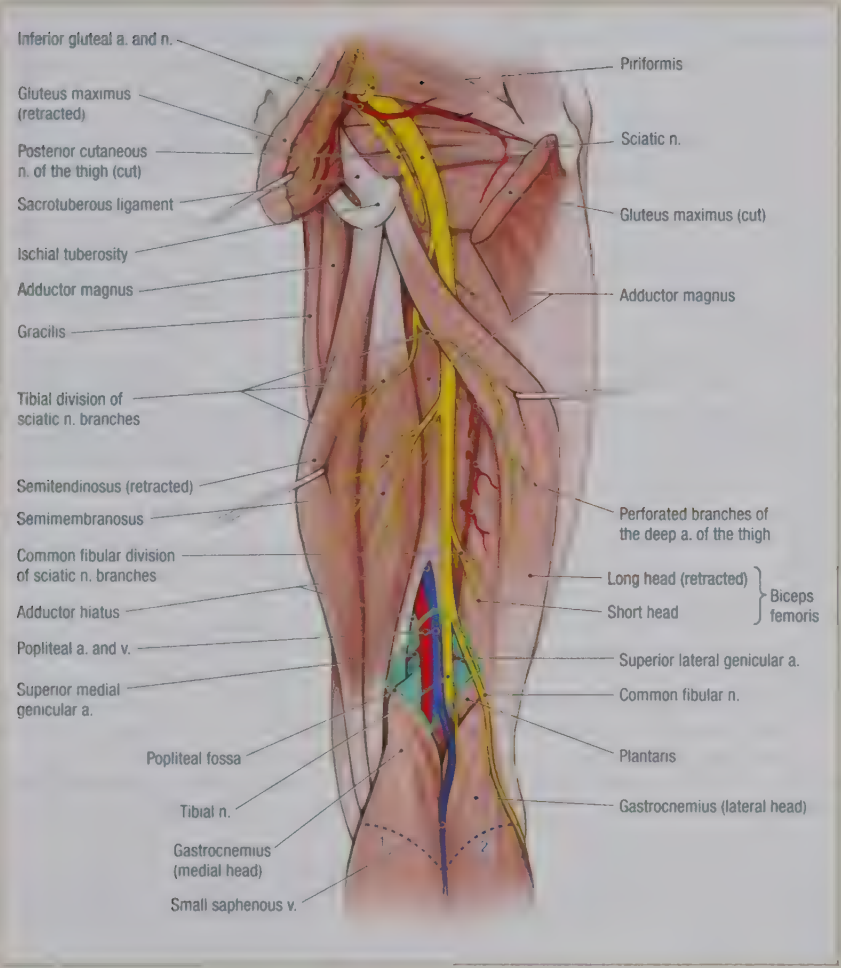

Inferior gluteal a. and n.
Gluteus maximus (retracted)
Posterior cutaneous n. of the thigh (cut)
Sacrotuberous ligament
Ischial tuberosity
Adductor magnus
Gracilis
Tibial division of sciatic n. branches
Semitendinosus (retracted)
Semimembranosus
Common fibular division of sciatic n. branches
Adductor hiatus
Popliteal a. and v.
Superior medial genicular a.
Popliteal fossa
Tibial n.
Gastrocnemius (medial head)
Small saphenous v.
Piriformis
Sciatic n.
Gluteus maximus (cut)
Adductor magnus
Perforated branches of the deep a. of the thigh
Long head (retracted)
Short head
Biceps femoris
Superior lateral genicular a.
Common fibular n.
Plantaris
Gastrocnemius (lateral head)
1
2

FIGURE 6.18 ● Contents of the posterior compartment of the right thigh and popliteal fossa. Posterior view.

10. On the medial side of the thigh, identify and clean the **semimembranosus muscle**. *Note that the semimembranosus ("half membrane") muscle is named for the broad, membrane-like tendon at its superior end.*
11. Lateral to the semimembranosus muscle, identify and clean the **semitendinosus muscle**. *Note that the semitendinosus ("half tendon") muscle is named for the long, cord-like tendon at its inferior end.*
12. Observe that inferiorly, the semitendinosus tendon passes posterior to the semimembranosus muscle.
13. Review the attachments and actions of the semimembranosus and semitendinosus muscles (see **TABLE 6.4**).
14. Follow the branches of the sciatic nerve and observe that it supplies the hamstring muscles through its **tibial division** and the short head of the biceps femoris through its **common fibular division**.

**CLINICAL CORRELATION**

### Sciatic Nerve Injury

ATLAS 6.33A, 6.33B

Sciatic nerve injury may result in significant peripheral neurologic deficits including paralysis of the flexors of the knee and all muscles below the knee, along with possible widespread numbness of the skin on the posterior aspect of the lower limb, the anterior side of the leg, and on the dorsal and plantar surfaces of the foot. Sciatica refers to radiating pain along the path of the sciatic nerve and is often caused by a herniated disc, spinal stenosis, or bone spurs.

15. Verify that the **hamstring part of the adductor magnus muscle** arises from the ischial tuberosity deep to the superior attachments of the posterior thigh muscles.
16. Observe that the adductor magnus muscle is in the medial compartment of the thigh and forms the anterior boundary of the posterior compartment of the thigh.

## Popliteal Fossa

ATLAS 6.41B, 6.42, 6.43; VIDEO 6.5.2

1. Refer to FIGURE 6.18.
2. Identify the borders of the diamond-shaped **popliteal fossa** beginning with the superolateral border, formed by the biceps femoris muscle, and the superomedial border, formed by the semitendinosus and semimembranosus muscles.
3. At the medial side of the knee, observe that the **sartorius, gracilis,** and **semitendinosus tendons** converge on the proximal end of the tibia in an arrangement that is named the pes anserinus for its goose-foot-like appearance. *Note that one muscle from each of the three compartments of the thigh is involved in the pes anserinus making knee flection an action of each.*
4. Identify the inferolateral border of the popliteal fossa, formed by the **lateral head of the gastrocnemius muscle** and the **plantaris muscle**, and the inferomedial border, formed by the **medial head of the gastrocnemius muscle**.
5. Observe that the popliteal fossa is bounded posteriorly by the skin and deep (popliteal) fascia and that anteriorly it is limited by the popliteal surface of the femur, the posterior surface of the knee joint capsule, and the popliteus muscle.
6. Observe that near the superior apex of the popliteal fossa, the sciatic nerve typically divides into the **tibial** and **common fibular nerves**, although this subdivision may occur higher in the posterior compartment or even in the gluteal region.
7. Use blunt dissection to follow the common fibular nerve laterally along the superolateral border of the popliteal fossa.
8. Observe that the common fibular nerve parallels the biceps femoris tendon and passes superficial to the lateral head of the gastrocnemius muscle and the plantaris muscle.
9. Use blunt dissection to separate the **tibial nerve** from the loose connective tissue that surrounds it and follow the nerve inferiorly.
10. Observe that the tibial nerve passes deep to the plantaris and gastrocnemius muscles at the inferior apex of the popliteal fossa.
11. Remove the remnants of the deep fascia (popliteal fascia) to expose the medial and lateral heads of the gastrocnemius muscle while sparing the branches of the tibial nerve.
12. At the inferior apex of the popliteal fossa, separate the two bellies of the gastrocnemius muscle and gently pull the muscle bellies apart for a distance of 5 to 10 cm.

***Dissection Note:*** Perform dissection steps 13 to 15 on only one lower limb.

13. On one lower limb, place a probe deep to the two heads of the gastrocnemius muscle just superior to the point where they join.
14. Transect both the medial and lateral heads of the muscle while sparing the branches of the **tibial nerve** and **popliteal artery (Cuts 1** and **2**).
15. Use blunt dissection to reflect the two heads superiorly and the bulk of the muscle belly inferiorly.
16. Refer to FIGURE 6.19.
17. Identify the **popliteal artery** and **vein** deep to the tibial nerve and observe that the popliteal artery and vein are enclosed by a connective tissue sheath.
18. Use scissors to cut the sheath of connective tissue enclosing the popliteal artery and vein and spread it open.
19. Use blunt dissection to separate the popliteal artery from the more superficially located popliteal vein.
20. Make an effort to preserve the popliteal vein as well as the **small (lesser) saphenous vein**, but remove the other venous tributaries to clear the dissection field.
21. Identify and clean the **superior lateral genicular artery** and the **superior medial genicular artery** deep in the popliteal fossa proximal to the attachments of the gastrocnemius muscle.
22. Follow the popliteal artery distally and observe that it passes deep to the plantaris and gastrocnemius muscles to enter the posterior compartment of the leg.
23. Retract the popliteal artery posteriorly and identify the **inferior lateral genicular artery** and the **inferior medial genicular artery** deep to the medial and lateral heads of the gastrocnemius muscle.

***Dissection Note:*** The genicular anastomosis formed by branches of the popliteal artery receives contributions from the femoral artery, lateral circumflex femoral artery, and the anterior tibial artery.

24. Retract the inferior end of the popliteal artery and vein and identify the **popliteus muscle**.
25. Observe that the floor of the popliteal fossa is partially formed by the popliteus muscle, which will be seen better when the posterior muscles of the leg are dissected.

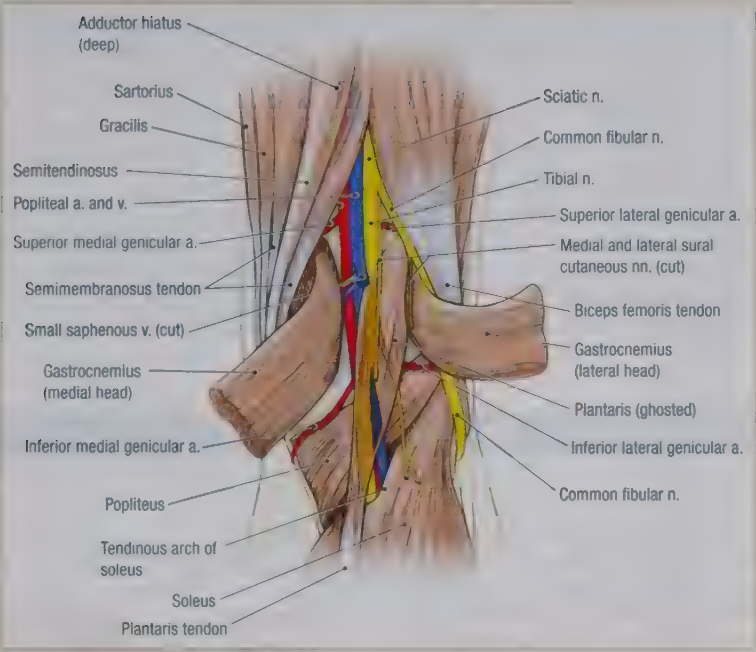

Adductor hiatus (deep)
Sartorius
Gracilis
Semitendinosus
Popliteal a. and v.
Superior medial genicular a.
Semimembranosus tendon
Small saphenous v. (cut)
Gastrocnemius (medial head)
Inferior medial genicular a.
Popliteus
Tendinous arch of soleus
Soleus
Plantaris tendon
Sciatic n.
Common fibular n.
Tibial n.
Superior lateral genicular a.
Medial and lateral sural cutaneous nn. (cut)
Biceps femoris tendon
Gastrocnemius (lateral head)
Plantaris (ghosted)
Inferior lateral genicular a.
Common fibular n.

FIGURE 6.19 ■ Contents of the right popliteal fossa. Posterior view.

## Dissection Follow-up

1. Using the dissected specimen, review the attachments and actions of the posterior thigh muscles as shown in **TABLE 6.4**.
2. Trace the course of the sciatic nerve from the pelvis to the knee and review its terminal branches.
3. Trace the femoral artery and vein from the level of the inguinal ligament to the popliteal fossa through the adductor hiatus, naming its branches.
4. Review the course of the deep artery of the thigh through the medial compartment of the thigh and review the course of its perforating vessels, which pass through the adductor magnus and brevis muscles to reach the posterior compartment of the thigh.
5. Review the genicular anastomosis around the knee.
6. Review the principal muscle groups of the thigh, the group functions, and the innervation of each muscle group.
7. Replace the muscles of the posterior compartment of the thigh into their correct anatomical positions.

**TABLE 6.4 | Muscles of the Posterior Thigh and Popliteal Fossa**

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Biceps femoris | Ischial tuberosity (long head)<br>Lateral lip of the linea aspera of femur (short head) | Head of the fibula | Extends the thigh (only long head) and flexes the leg | Tibial division of the sciatic n. (long head) and common fibular division of the sciatic n. (short head) |
| Semitendinosus | Ischial tuberosity | Medial surface of the superior part of the tibia | Extends the thigh and flexes and medially rotates the leg | Tibial division of the sciatic n. |
| Semimembranosus |  | Posterior part of the medial condyle of the tibia |  |  |
| Popliteus | Lateral surface of lateral condyle of femur and lateral meniscus | Posterior surface of tibia superior to soleal line | Unlocks fully extended leg, weak flexor of leg | Tibial n. |

Abbreviation: n., nerve.

# POSTERIOR COMPARTMENT OF THE LEG

## Dissection Overview

The two bones of the leg are unequal in size. The larger tibia is the weight-bearing bone of the leg. The fibula is surrounded by muscles except at its proximal and distal ends. The tibia and fibula are joined by an interosseous membrane as shown in FIGURE 6.20. The crural fascia is attached to the fibula by two intermuscular septa: anterior and posterior. The tibia, fibula, interosseous membrane, and intermuscular septa divide the leg into three compartments: posterior, lateral (fibular), and anterior.

The posterior compartment of the leg lies posterior to the tibia, interosseous membrane, and fibula. A transverse intermuscular septum divides the muscles of the posterior compartment into superficial and deep groups. The superficial posterior group contains three muscles: gastrocnemius, soleus, and plantaris. The combined action of the superficial posterior muscle group is flexion of the knee and plantar flexion of the foot. The deep posterior group contains four muscles: popliteus, tibialis posterior, flexor digitorum longus, and flexor hallucis longus. The shared actions of the deep posterior muscle group are inversion of the foot, plantar flexion of the foot, and flexion of the toes. The tibial nerve innervates both the superficial and deep posterior muscle groups.

The order of dissection will be as follows: The superficial veins and cutaneous nerves of the posterior side of the leg will be reviewed. The crural fascia of the posterior side of the leg will be opened, and the superficial posterior group of leg muscles will be examined. The muscles in the superficial posterior group will be reflected to expose the muscles of the deep posterior group. The vessels and nerves of the posterior compartment will be dissected. The muscles of the deep posterior group will be identified.

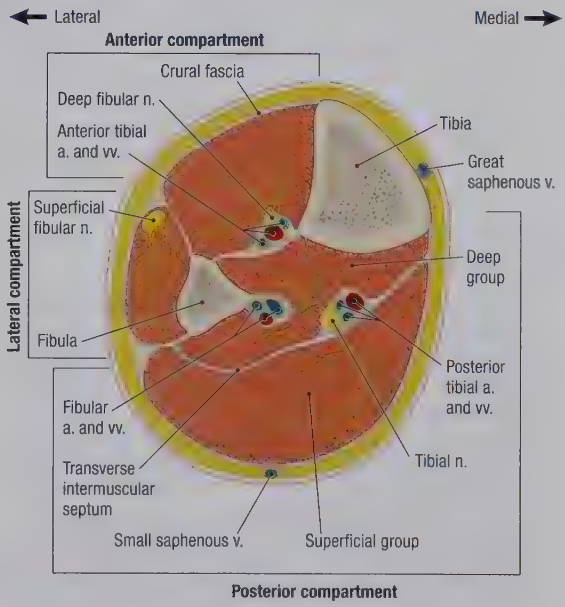

← Lateral
Medial →
Anterior compartment
Crural fascia
Deep fibular n.
Anterior tibial a. and vv.
Tibia
Great saphenous v.
Lateral compartment
Superficial fibular n.
Deep group
Fibula
Posterior tibial a. and vv.
Fibular a. and vv.
Tibial n.
Transverse intermuscular septum
Small saphenous v.
Superficial group
Posterior compartment

FIGURE 6.20 ● Axial section through the right leg. Inferior view.

## Skeletal Anatomy

Refer to an articulated skeleton or disarticulated tibia and fibula to identify the following skeletal features.

### *Posterior Tibia and Fibula*

ATLAS 6.65B

1. Refer to FIGURE 6.21.
2. On the proximal aspect of the **tibia** medially and laterally, identify the flattened articular surfaces of the **medial condyle** and **lateral condyle**, respectively.
3. Between the medial and lateral condyles, identify the **intercondylar eminence**, the roughened process for attachment of the cruciate ligaments of the knee.
4. On the posterior aspect of the proximal tibia, identify the obliquely oriented **soleal line**.
5. On the inferior aspect of the tibia medially, identify the large protrusion of the **medial malleolus**.
6. On the proximal aspect of the **fibula**, identify the boxlike **head** of the fibula superior to the narrowed region of the **neck**.
7. Follow the length of the fibula inferiorly along the **shaft (body)** to the triangular-shaped **lateral malleolus**.
8. Place the tibia and fibula side by side in anatomical position and observe that the fibula does not align with the superior surface of the tibia, extends further inferiorly than the tibia, does not articulate at the knee, and functions as a non–weight-bearing bone at both the ankle and the knee.

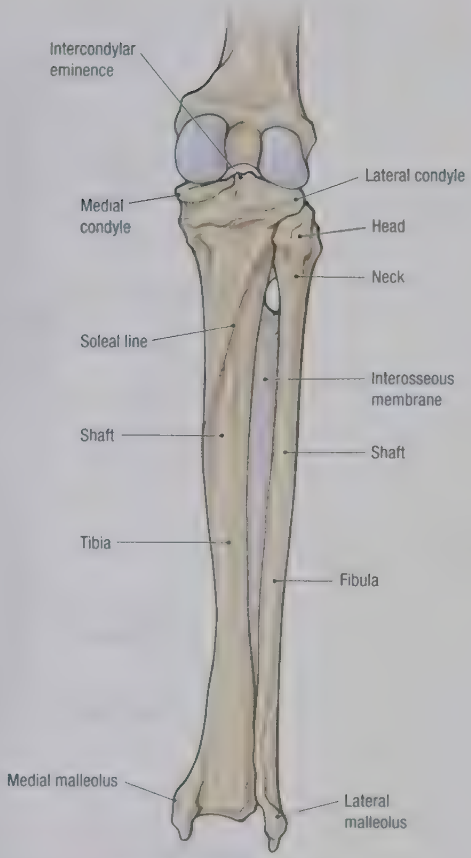


FIGURE 6.21 ● Skeleton of the right leg. Posterior view.

## Dissection Instructions

### Superficial Compartment of Posterior Leg

ATLAS 6.66B, 6.66C; VIDEO 6.6.1

1. Refer to FIGURE 6.22.
2. With the cadaver in the prone position, use scissors to make a vertical cut through the crural fascia from the popliteal fossa to the calcaneal tuberosity.
3. Use blunt dissection to spread the crural fascia and expose the posterior compartment of the leg.
4. Reflect the cut portions of the **gastrocnemius muscle** superiorly and inferiorly on the side the incisions were made and identify the **soleus muscle**.
5. Identify the tendon of the **plantaris muscle** between the lateral head of the gastrocnemius and the soleus.
6. Follow the tendon of the plantaris muscle superiorly and observe that the muscle belly lies in the popliteal fossa. *Note that the plantaris muscle may be absent in a small percentage of cases.*
7. Follow the plantaris tendon inferiorly and observe that it either joins the **calcaneal (Achilles) tendon**, the common tendon of the gastrocnemius and soleus muscles, or attaches to the calcaneal tuberosity independently.
8. Review the attachments and actions of the superficial posterior group of leg muscles (see **TABLE 6.5**).

### Deep Compartment of Posterior Leg

ATLAS 6.67C, 6.68A; VIDEO 6.6.2

1. Refer to FIGURE 6.22.
2. Follow the **tibial nerve** and **posterior tibial vessels** from where they exit the popliteal fossa and observe that they pass deep (anterior) to the tendinous arch of the soleus muscle.
3. Observe that the **tibial nerve** and **posterior tibial vessels** course distally within the **transverse intermuscular septum** that separates the superficial posterior muscle group from the deep posterior muscle group.

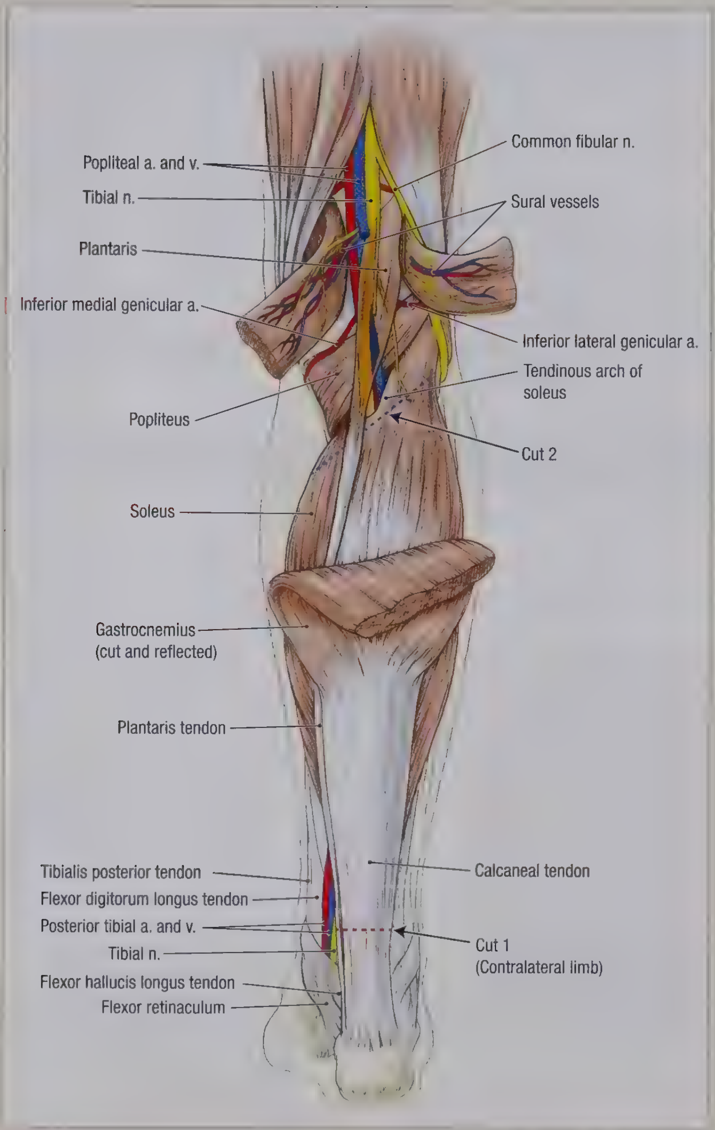

Popliteal a. and v.
Tibial n.
Plantaris
Inferior medial genicular a.
Popliteus
Soleus
Gastrocnemius (cut and reflected)
Plantaris tendon
Tibialis posterior tendon
Flexor digitorum longus tendon
Posterior tibial a. and v.
Tibial n.
Flexor hallucis longus tendon
Flexor retinaculum
Common fibular n.
Sural vessels
Inferior lateral genicular a.
Tendinous arch of soleus
Cut 2
Calcaneal tendon
Cut 1 (Contralateral limb)

FIGURE 6.22 ■ Superficial posterior compartment of the right leg. Posterior view.

***Dissection Note:*** To better see the deep muscle layer, the soleus muscle must be reflected. Steps 4, 5, and 6 should only be performed on the contralateral limb to where the gastrocnemius was transected, and step 7 should be skipped on that limb.

4. On the contralateral side of the body where the gastrocnemius was transected, cut the calcaneal tendon about 5 cm superior to the tuberosity of the calcaneus (**Cut 1**).
5. Elevate the calcaneal tendon superiorly and use your fingers to separate the calcaneal tendon from the muscles in the deep posterior group of leg muscles.
6. On the ipsilateral side of the body where the gastrocnemius was transected, cut the soleus muscle beginning at its tibial (medial) attachment extending across the leg to its fibular attachment (**Cut 2**). This cut should pass 2 cm inferior to the tendinous arch of the soleus muscle.
7. Leave the soleus attached to both the calcaneal tendon and the fibula and reflect the soleus muscle and the distal part of the gastrocnemius muscle laterally to expose the transverse intermuscular septum.
8. Refer to FIGURE 6.23.

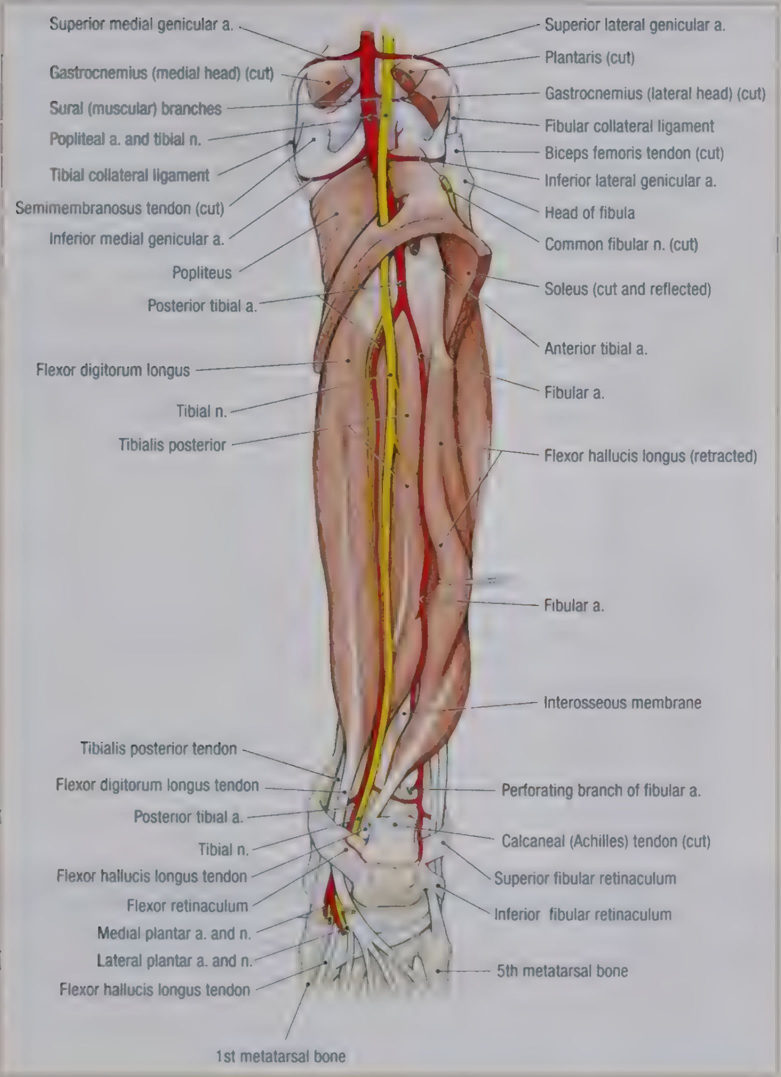

Superior medial genicular a.
Gastrocnemius (medial head) (cut)
Sural (muscular) branches
Popliteal a. and tibial n.
Tibial collateral ligament
Semimembranosus tendon (cut)
Inferior medial genicular a.
Popliteus
Posterior tibial a.
Flexor digitorum longus
Tibial n.
Tibialis posterior
Superior lateral genicular a.
Plantaris (cut)
Gastrocnemius (lateral head) (cut)
Fibular collateral ligament
Biceps femoris tendon (cut)
Inferior lateral genicular a.
Head of fibula
Common fibular n. (cut)
Soleus (cut and reflected)
Anterior tibial a.
Fibular a.
Flexor hallucis longus (retracted)
Fibular a.
Interosseous membrane
Tibialis posterior tendon
Flexor digitorum longus tendon
Posterior tibial a.
Tibial n.
Flexor hallucis longus tendon
Flexor retinaculum
Medial plantar a. and n.
Lateral plantar a. and n.
Flexor hallucis longus tendon
1st metatarsal bone
Perforating branch of fibular a.
Calcaneal (Achilles) tendon (cut)
Superior fibular retinaculum
Inferior fibular retinaculum
5th metatarsal bone

FIGURE 6.23 ■ Deep posterior compartment of the right leg. Posterior view.

9. Identify the **posterior tibial artery and vein** and the **tibial nerve** within the transverse intermuscular septum.
10. Observe that the posterior tibial artery is usually accompanied by two veins, the venae comitantes, and thus can be distinguished from the tibial nerve. Remove the veins to clear the dissection field.
11. Use blunt dissection to follow the posterior tibial artery and the tibial nerve proximally and observe that the popliteal artery bifurcates at the inferior border of the popliteus muscle to the **anterior** and **posterior tibial arteries**.
12. Superior to the superior extent of the soleus, identify the **popliteus muscle**.
13. To better visualize the popliteus muscle, gently retract the contents of the popliteal fossa laterally.
14. Observe that the popliteus muscle fibers course through the popliteal fossa at an oblique angle from inferomedial to superolateral.
15. Deep to the soleus muscle, identify the **tibialis posterior muscle** directly posterior to the tibia.
16. Medial to the tibialis posterior muscle, identify the **flexor digitorum longus muscle**.
17. Lateral to the tibialis posterior muscle, identify the **flexor hallucis longus muscle**. Observe that the bulk of the muscle belly of the flexor hallucis longus lies deep to the soleus on the lateral side of the leg, but its

tendon crosses the ankle to the medial side with the tendons of the other deep posterior group muscles.

18. Review the attachments and actions of the deep posterior group of leg muscles (see **TABLE 6.5**).
19. Posterior to the medial malleolus and deep to the flexor retinaculum, observe that the **posterior tibial artery** and the **tibial nerve** lie between the tendons of the flexor digitorum longus and flexor hallucis longus muscles.

***Dissection Note:*** Posterior to the medial malleolus, the following mnemonic device may be used to identify the tendons and vessels in anterior to posterior order: **T**om, **D**ick and **A** **V**ery **N**ervous **H**arry (**T**ibialis posterior, flexor **D**igitorum longus, posterior tibial **A**rtery, posterior tibial **V**ein, tibial **N**erve, flexor **H**allucis longus). *Note that the tibialis posterior muscle tendon crossed under the flexor digitorum longus muscle tendon making the order of tendons from medial to lateral: tibialis posterior, flexor digitorum longus, flexor hallucis longus.*

20. In the upper part of the posterior leg, between the tibialis posterior muscle and the flexor hallucis longus muscle, identify the **fibular artery** arising from the posterior tibial artery about 2 or 3 cm distal to the inferior border of the popliteus muscle. *Note that the fibular artery supplies blood to the muscles of the lateral compartment of the leg and lateral side of the posterior compartment of the leg by means of several small branches.*
21. Identify the **perforating branch of the fibular artery** just superior to the ankle joint where it perforates the interosseous membrane. *Note that the perforating branch of the fibular artery anastomoses with a branch of the anterior tibial artery. Occasionally, the perforating branch of the fibular artery will give rise to the dorsalis pedis artery.*

## Dissection Follow-up

1. Use the dissected specimen to review the attachments and actions of each muscle in the posterior compartment of the leg as shown in **TABLE 6.5**.
2. Follow the popliteal artery into the posterior compartment of the leg and identify its branches.
3. Follow the posterior tibial artery distally and identify the origin of the fibular artery and review the distribution of the arteries of the posterior compartment of the leg.
4. Follow the tibial nerve through the popliteal fossa and posterior compartment of the leg, observing that it gives numerous muscular branches.
5. Review the relationships of the nerve, tendons, and vessels posterior to the medial malleolus and use this pattern to organize the contents of the deep posterior compartment of the leg.
6. Review the pattern of innervation of the posterior compartment of the leg.
7. Replace the muscles of the posterior compartment of the leg into their correct anatomical positions.

**TABLE 6.5 | Muscles of the Posterior Leg**

| SUPERFICIAL GROUP | | | | |
|---|---|---|---|---|
| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
| Gastrocnemius | Superior to the lateral and medial femoral condyles | Posterior surface of calcaneus via calcaneal tendon | Plantarflexes the foot and flexes the knee | Tibial n. |
| Plantaris | Lateral supracondylar line of the femur | | | |
| Soleus | Soleal line of the tibia and head of the fibula | | Plantarflexes the foot | |
| DEEP GROUP | | | | |
| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
| Popliteus | Lateral surface of lateral condyle of femur and lateral meniscus | Posterior surface of tibia superior to soleal line | Unlocks fully extended leg; weakly flexes the knee | Tibial n. |
| Tibialis posterior | Tibia, fibula, and interosseous membrane | Navicular, cuneiform, cuboid, and bases of metatarsals 2–4 | Inverts and plantarflexes the foot | |
| Flexor digitorum longus | Medial part of posterior surface of tibia inferior to the soleal line | Bases of the distal phalanges of the lateral four toes | Flexes toes 2–5 and plantarflexes the foot | |
| Flexor hallucis longus | Inferior two-thirds of the fibula and interosseous membrane | Base of the distal phalanx of the great toe | Flexes the great toe and plantarflexes the foot | |

Abbreviation: n., nerve.

# LATERAL COMPARTMENT OF THE LEG

## Dissection Overview

The lateral compartment of the leg contains two muscles: the fibularis brevis and the fibularis longus. The two muscles of the lateral compartment of the leg are innervated by the superficial fibular nerve and combine to produce eversion and plantarflexion of the foot.

The order of dissection will be as follows: The lateral aspect of the crural fascia will be examined and opened. The fibular retinaculum will be studied. The superficial fibular nerve will be examined on the lateral surface of the leg. The tendons of each muscle of the lateral compartment will be followed posterior to the lateral malleolus.

## Dissection Instructions

### Lateral Compartment of the Leg

ATLAS 6.59B, 6.59C; VIDEO 6.7.1

***Dissection Note:*** Depending on the orientation of the foot, the lateral compartment of the leg may be easier to access with the body either prone or supine. Turn the cadaver to whichever orientation facilitates the dissection.

1. Refer to FIGURE 6.24.
2. Examine the crural fascia on the lateral side of the leg and identify the **fibular retinaculum**, a thickening of the crural fascia found on the lateral side of the ankle posterior to the lateral malleolus attaching to the calcaneus, which assists in holding down the fibularis longus and brevis tendons.
3. Observe that the fibular retinaculum may be subdivided into a **superior** portion, which attaches to the lateral malleolus of the fibula, and an **inferior** portion, which attaches to the extensor retinaculum of the foot.
4. About two-thirds of the way down the leg, identify the superficial fibular nerve where it penetrates the crural fascia. Recall that the superficial fibular nerve is a branch of the common fibular nerve.
5. Follow the superficial fibular nerve distally to the dorsum of the foot and observe that it gives rise to several **dorsal digital branches**. *Note that the superficial fibular nerve is the primary cutaneous nerve of the dorsum of the foot.*
6. Use scissors to cut the crural fascia overlying the lateral compartment of the leg as far inferiorly as the superior fibular retinaculum.
7. In the superior leg, observe that the **fibularis longus muscle** is attached to the inner surface of the crural fascia.
8. Use a scalpel to carefully detach the fibularis longus muscle from the crural fascia using a similar technique to skinning.

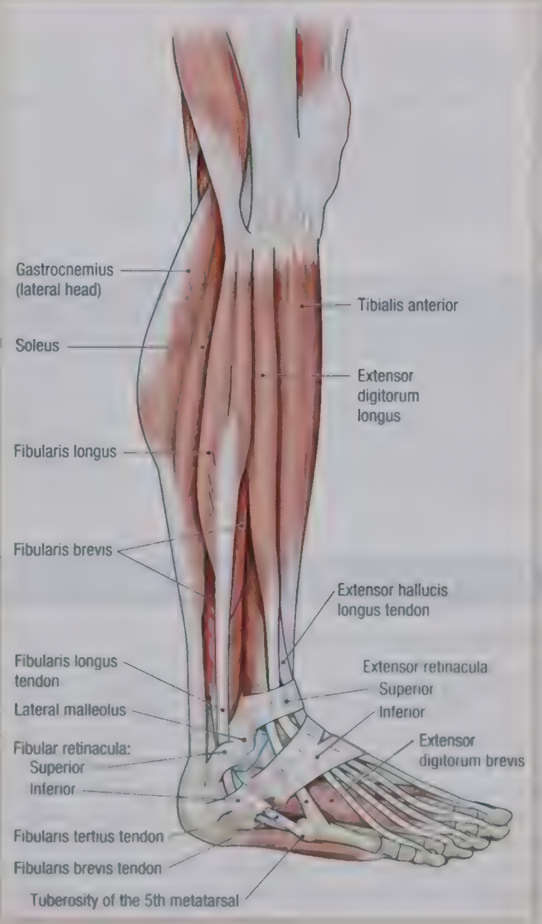

Gastrocnemius (lateral head)
Tibialis anterior
Soleus
Extensor digitorum longus
Fibularis longus
Fibularis brevis
Extensor hallucis longus tendon
Fibularis longus tendon
Extensor retinacula
Superior
Inferior
Lateral malleolus
Fibular retinacula:
Superior
Inferior
Extensor digitorum brevis
Fibularis tertius tendon
Fibularis brevis tendon
Tuberosity of the 5th metatarsal

FIGURE 6.24 ● Lateral compartment of the right leg. Lateral view.

9. Use blunt dissection to follow and separate the tendons of the **fibularis brevis** and **fibularis longus muscles** distally.
10. Observe that the fibularis longus and brevis muscle tendons pass posterior to the lateral malleolus, deep to the superior and inferior fibular retinacula. *Note that the tendon of the fibularis brevis is anterior to the tendon of the fibularis longus where they pass posterior to the lateral malleolus.*
11. Follow the tendon of the fibularis brevis muscle inferiorly to its distal attachment on the tuberosity of the 5th metatarsal bone on the lateral aspect of the foot.
12. Follow the tendon of the fibularis longus muscle inferiorly to the point where it turns around the lateral side of the cuboid bone to enter the sole of the foot. *Note that the tendon of the fibularis longus muscle attaches to the plantar surface of the medial cuneiform and 1st metatarsal bones.*
13. Review the attachments and actions of the lateral group of leg muscles (see **TABLE 6.6**).

## Dissection Follow-up

1. Use the dissected specimen to review the attachments and actions of the muscles in the lateral compartment of the leg as shown in **TABLE 6.6**.
2. Review the blood supply to the muscles of the lateral compartment of the leg.
3. Review the pattern of innervation for the lateral compartment of the leg.
4. Replace the muscles of the lateral compartment of the leg into their correct anatomical positions.

**TABLE 6.6** **Muscles of the Lateral Leg**

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Fibularis longus | Head and superior two-thirds of lateral surface of fibula | Base of 1st metatarsal and medial cuneiform | Evert and plantarflex the foot | Superficial fibular n. |
| Fibularis brevis | Inferior two-thirds of lateral surface of fibula | Tuberosity of the 5th metatarsal bone | | |

Abbreviation: n., nerve.

# ANTERIOR COMPARTMENT OF THE LEG AND DORSUM OF THE FOOT

## Dissection Overview

The anterior compartment of the leg contains four muscles: tibialis anterior, extensor hallucis longus, extensor digitorum longus, and fibularis tertius. The muscles of the anterior compartment of the leg are innervated by the deep fibular nerve and produce dorsiflexion and inversion of the foot and extension of the toes.

The order of dissection will be as follows: The distribution of cutaneous nerves over the lower anterior surface of the leg and dorsal surface of the foot will be reviewed. The anterior aspect of the deep fascia of the leg and foot will be examined, and the extensor retinacula will be identified. The anterior compartment of the leg will be opened, and the relationships of tendons, vessels, and nerves will be examined on the anterior surface of the ankle. The tendon of each muscle of the anterior compartment will be followed into the foot. The intrinsic muscles of the dorsum of the foot will be identified. The deep vessels and deep nerve of the leg and dorsum of the foot will be dissected.

### Skeletal Anatomy

Refer to an articulated skeleton of the bones of the foot to identify the following skeletal features.

#### *Anterior Tibia and Fibula*

ATLAS 6.58B

1. Refer to FIGURE 6.25.
2. On the proximal aspect of the **tibia** medially and laterally, identify the flattened articular surfaces of the **medial condyle** and **lateral condyle**, respectively.

3. On the anterior aspect of the proximal tibia, identify the **tibial tuberosity** the roughened portion of bone serving as the distal attachment of the patellar tendon.
4. On the anterior aspect of the **shaft of the tibia**, identify the sharp ridge of the **anterior border**.
5. On the proximal aspect of the **fibula**, identify the boxlike **head** of the fibula superior to the narrowed region of the **neck**.
6. Follow the length of the fibula inferiorly along the **shaft (body)** to the triangular-shaped **lateral malleolus**.
7. Place the tibia and fibula side by side in anatomical position and observe that the fibula does not align with the superior surface of the tibia, extends further inferiorly than the tibia, does not articulate at the knee, and functions as a non–weight-bearing bone at both the ankle and the knee.
8. On an articulated skeleton, observe that the **patella** articulates with the femur.

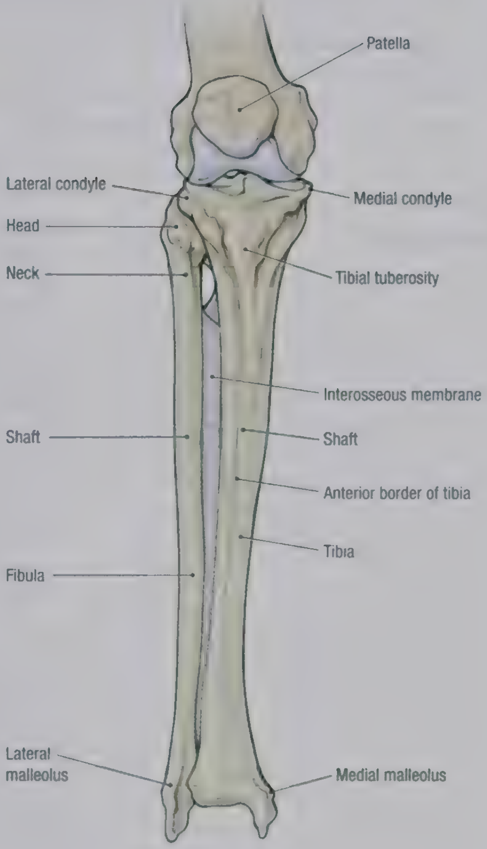

Patella
Lateral condyle
Medial condyle
Head
Neck
Tibial tuberosity
Interosseous membrane
Shaft
Shaft
Anterior border of tibia
Tibia
Fibula
Lateral malleolus
Medial malleolus

FIGURE 6.25 ● Skeleton of the right leg. Anterior view.

## *Skeleton of the Dorsal Foot*

ATLAS 6.61A, 6.63D, 6.67E

1. Refer to FIGURE 6.26.
2. In the articulated foot, identify the seven tarsal bones beginning with the "heel bone," the **calcaneus**.
3. Superior to the calcaneus, identify the **talus**. On an articulated skeleton, observe that the superior aspect of the talus articulates with the inferior aspect of the tibia.
4. Anterior to the talus medially, identify the "boat-shaped" **navicular** bone.
5. Observe that on the medial aspect of the foot, the navicular articulates on its anterior surface with the three **cuneiform bones**: 1st (medial), 2nd (intermediate, middle), and 3rd (lateral).
6. On the lateral aspect of the foot, lateral to the lateral cuneiform and navicular bones, identify the last of the tarsal bones, the **cuboid**.
7. Observe that the cuboid articulates with the anterior aspect of the calcaneus on the lateral aspect of the foot.

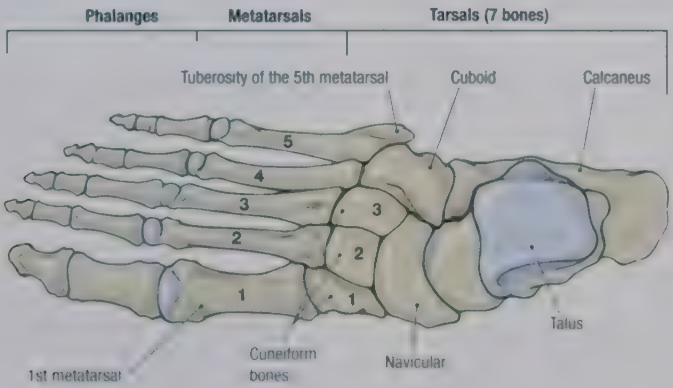

Phalanges
Metatarsals
Tarsals (7 bones)
Tuberosity of the 5th metatarsal
Cuboid
Calcaneus
5
4
3
2
1
3
2
1
Talus
1st metatarsal
Cuneiform bones
Navicular

FIGURE 6.26 ● Skeleton of the right foot. Superior (dorsal) view.

8. Distal to the tarsal bones, identify the five **metatarsal bones** beginning with the 1st metatarsal on the medial aspect of the foot and ending with the 5th metatarsal on the lateral aspect of the foot.
9. Identify the **tuberosity of the 5th metatarsal bone** and observe that it extends laterally past the cuboid and serves as a site of muscle attachment.
10. Distal to the metatarsals, identify the fourteen **phalanges** and observe that the 1st toe has only two phalanges, whereas the other toes each have three phalanges.

## Dissection Instructions

### Crural Fascia

ATLAS 6.15A; VIDEO 6.8.1

1. Refer to FIGURE 6.27.
2. Place the cadaver in the supine position.
3. Remove the remnants of superficial fascia on the anterior surface of the leg and dorsum of the foot so the **crural fascia** and deep fascia of the foot are clearly exposed making an effort to preserve the branches of the **superficial fibular nerve**. *Note that the superficial fibular nerve provides most of the cutaneous innervation to the anterior surface of the ankle and dorsum of the foot.*
4. Observe the crural fascia and note that it is firmly attached to the anterior border of the tibia.
5. Identify the **superior** and **inferior extensor retinacula** on the anterior surface of the ankle, the transverse thickenings of the crural fascia that hold the tendons of the anterior compartment in place.
6. Observe that the superior extensor retinaculum extends across the tendons of the anterior compartment muscles superior to the ankle joint and that the inferior extensor retinaculum is at the level of the ankle joint and is Y-shaped with the stem of the "Y" directed laterally attaching to the calcaneus.
7. Make a vertical cut through the crural fascia just below the lateral condyle of the tibia along the anterior tibial border.
8. Use forceps to lift the edges of the crural fascia and observe that the muscles of the anterior compartment are attached to its deep surface.
9. Extend the vertical cut distally through the crural fascia while sparing the extensor retinacula.
10. Reflect and remove the crural fascia by peeling it away from the muscles of the anterior compartment. *Note that the superior attachments of the anterior muscles of the leg are on the proximal tibia, fibula, and interosseous membrane. Do not attempt to dissect the superior attachments.*

### Anterior Compartment of the Leg

ATLAS 6.57, 6.59B; VIDEO 6.8.2

1. Refer to FIGURE 6.27.
2. Use blunt dissection to separate the vessels, nerves, and tendons of the anterior muscles of the leg where they pass deep to the inferior extensor retinaculum.
3. Identify the **tibialis anterior tendon** anterior to the medial malleolus.
4. Observe that the tibialis anterior tendon and the tibialis posterior tendon are the two tendons closest to the medial malleolus, and they are named according to their location relative to the bone.
5. Follow the tendon of the **tibialis anterior muscle** into the foot toward its attachment to the 1st cuneiform bone and the base of the 1st metatarsal bone.
6. Lateral to the tibialis anterior, identify the **extensor hallucis longus tendon** and follow it into the foot toward its attachment to the base of the distal phalanx of the great toe.
7. At the level of the superior extensor retinaculum, identify the **anterior tibial artery** deep to the extensor hallucis longus tendon and follow it proximally.
8. Use blunt dissection to separate the extensor digitorum longus muscle from the tibialis anterior muscle.
9. Use blunt dissection to clean the anterior tibial artery where it passes posteriorly over the superior border of the interosseous membrane.
10. Observe that the **deep fibular nerve** travels with the anterior tibial artery just below the knee. *Note that the deep fibular nerve is the motor nerve of the anterior compartment of the leg and the muscles in the dorsum of the foot.*
11. Trace the deep fibular nerve proximally and confirm that it is a branch of the **common fibular nerve**.

**CLINICAL CORRELATION**

### Common Fibular Nerve Injury

ATLAS 6.62B

The common fibular nerve is one of the most frequently injured nerves in the body because of its superficial position and relationship to the head and neck of the fibula. When the common fibular nerve is injured, there is impairment of eversion of the foot, dorsiflexion of the foot, and extension of the toes in a condition called "foot drop." In foot drop, or steppage gait, the advancing foot hangs with the toes pointed toward the ground while the knee is lifted high enough so that the toes may clear the ground. Foot drop is also accompanied by sensory loss on the dorsum of the foot and toes.

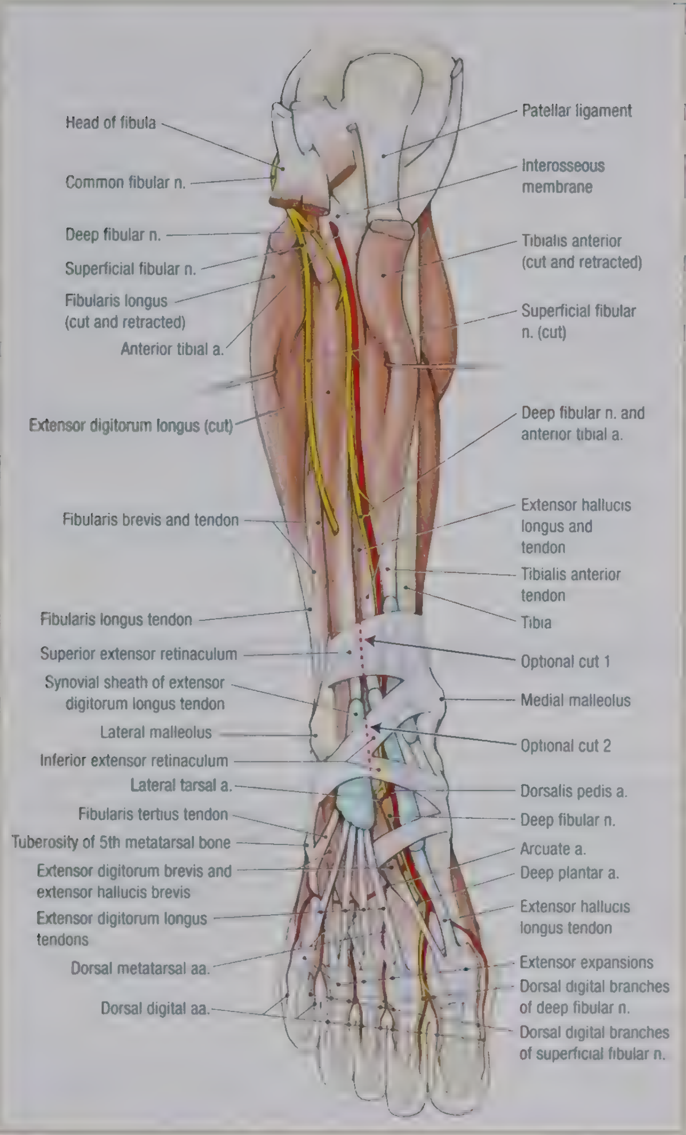

Head of fibula
Common fibular n.
Deep fibular n.
Superficial fibular n.
Fibularis longus (cut and retracted)
Anterior tibial a.
Extensor digitorum longus (cut)
Fibularis brevis and tendon
Fibularis longus tendon
Superior extensor retinaculum
Synovial sheath of extensor digitorum longus tendon
Lateral malleolus
Inferior extensor retinaculum
Lateral tarsal a.
Fibularis tertius tendon
Tuberosity of 5th metatarsal bone
Extensor digitorum brevis and extensor hallucis brevis
Extensor digitorum longus tendons
Dorsal metatarsal aa.
Dorsal digital aa.
Patellar ligament
Interosseous membrane
Tibialis anterior (cut and retracted)
Superficial fibular n. (cut)
Deep fibular n. and anterior tibial a.
Extensor hallucis longus and tendon
Tibialis anterior tendon
Tibia
Optional cut 1
Medial malleolus
Optional cut 2
Dorsalis pedis a.
Deep fibular n.
Arcuate a.
Deep plantar a.
Extensor hallucis longus tendon
Extensor expansions
Dorsal digital branches of deep fibular n.
Dorsal digital branches of superficial fibular n.

FIGURE 6.27 ● Anterior compartment of the right leg and dorsum of the foot. Anterior view.

12. Lateral to the extensor hallucis longus tendon, identify the tendons of the **extensor digitorum longus muscle** and follow them distally to confirm that they attach to the **extensor expansions** of the lateral four toes.
13. On the lateral aspect of the extensor digitorum longus muscle, identify the tendon of the **fibularis tertius muscle** and follow its tendon to confirm its inferior attachment on the dorsal surface of the shaft of the 5th metatarsal bone. *Note that the fibularis tertius muscle is absent in some individuals.*
14. If the neurovascular structures and tendons of the anterior compartment are not clearly visible, use scissors to cut the superior (**Optional Cut 1**)

and inferior extensor retinacula (**Optional Cut 2**) between the extensor digitorum longus and extensor hallucis longus tendons. Retract the tendons of the extensor digitorum longus muscle in the lateral direction.

15. Review the attachments and actions of the anterior group of leg muscles (see **TABLE 6.7**).

### Dorsum of the Foot

ATLAS 6.60, 6.61B; VIDEO 6.8.3

1. Refer to FIGURE 6.27.
2. On the dorsum of the foot deep to the tendons of the extensor digitorum longus muscle, identify the **extensor digitorum brevis muscle** and the **extensor hallucis brevis muscle**, which share a common muscle belly attaching to the calcaneus.
3. Identify the four tendons arising from the common muscle belly to attach to the extensor expansions of toes 2 to 5. *Note that the portion of this muscle that attaches on the great toe is called the extensor hallucis brevis muscle.*
4. Review the attachments, and actions, of the muscles on the dorsum of the foot (see **TABLE 6.7**).
5. Return to the ankle and trace the anterior tibial artery deep to the inferior extensor retinaculum where it crosses the ankle joint, and its name changes to **dorsalis pedis artery**.
6. Follow the dorsalis pedis artery onto the dorsum of the foot and observe that it lies on the lateral side of the extensor hallucis longus tendon at the ankle. *Note that in the living person, the pulse of the dorsalis pedis artery can be palpated between the tendons of the extensor hallucis longus muscle and the extensor digitorum longus muscle.*
7. Deep to the tendons on the dorsum of the foot, identify the **arcuate artery**, a branch of the dorsalis pedis artery that crosses the proximal ends of the metatarsal bones. The lateral three **dorsal metatarsal arteries** are branches of the arcuate artery.
8. Identify the **lateral tarsal artery** arising from the dorsalis pedis artery near the ankle joint passing deep to the extensor digitorum brevis and extensor hallucis brevis muscles. *Note that the lateral tarsal artery joins the lateral end of the arcuate artery to complete an arterial arch.*
9. Identify the **deep plantar artery** arising from the dorsalis pedis artery near the origin of the arcuate artery.
10. Observe that the deep plantar artery passes between the 1st and 2nd metatarsal bones to enter the sole of the foot to anastomose with the plantar arch.
11. At the level of the ankle, identify the **deep fibular nerve** between the tendons of the extensor hallucis longus and extensor digitorum longus muscles.
12. Use blunt dissection to follow the deep fibular nerve onto the dorsum of the foot. *Note that the deep fibular nerve innervates the extensor digitorum brevis muscle and extensor hallucis brevis muscle.*
13. Trace the cutaneous branch of the deep fibular nerve to the region of skin between the great toe and the 2nd toe and identify the two **dorsal digital branches**. *Note that the skin between the great toe and the 2nd toe is the only skin on the dorsum of the foot that is innervated by the deep fibular nerve.*

## Dissection Follow-up

1. Use the dissected specimen to review the attachments and actions of the muscles in the anterior compartment of the leg as shown in **TABLE 6.7**.
2. Trace the anterior tibial artery through the anterior compartment of the leg to the foot and identify where its name changes to the dorsalis pedis artery.
3. Review the pattern of innervation for the anterior compartment of the leg and the dorsum of the foot.
4. Review the principal muscle groups of the leg, the group functions, and the innervation of each muscle group.
5. Replace the muscles of the anterior compartment of the leg and dorsum of the foot into their correct anatomical positions.

**TABLE 6.7 | Muscles of the Anterior Leg and Dorsum of Foot**

| Muscle | Proximal Attachments | Distal Attachments | Actions | Innervation |
|---|---|---|---|---|
| ANTERIOR LEG | | | | |
| Tibialis anterior | Lateral condyle and superior half of lateral surface of tibia | Base of 1st metatarsal and medial and inferior surfaces of medial cuneiform | Dorsiflexes and inverts the foot | Deep fibular n. |
| Extensor hallucis longus | Middle part of anterior surface of fibula and interosseous membrane | Dorsal aspect of base of distal phalanx of great toe | Extends great toe and dorsiflexes foot | |
| Extensor digitorum longus | Lateral condyle of tibia and superior three-fourths of anterior surface of interosseous membrane | Extensor expansion to distal phalanges of lateral four digits | Extends lateral four digits and dorsiflexes foot | |
| Fibularis tertius | Inferior third of anterior surface of fibula and interosseous membrane | Dorsum of base of 5th metatarsal | Dorsiflexes and everts foot | |
| DORSUM OF FOOT | | | | |
| Muscle | Proximal Attachments | Distal Attachments | Actions | Innervation |
| Extensor digitorum brevis | Calcaneus, floor of the tarsal sinus | Extensor expansions of digits 2–5 | Extends digits | Deep fibular n. |
| Extensor hallucis brevis | Calcaneus, floor of the tarsal sinus | Extensor expansion of digit 1 | Extends great toe | |

Abbreviation: n., nerve.

# SOLE OF THE FOOT

## Dissection Overview

The foot is arched both longitudinally and transversely, with the weight-bearing points at the calcaneus posteriorly, and the heads of the five metatarsal bones anteriorly. The plantar aponeurosis supports the longitudinal arch along with the deeper located long and short plantar ligaments, and the spring ligament. Deep to the plantar aponeurosis are four layers of intrinsic foot muscles, tendons, vessels, and nerves. The axis of reference for the toe movements of abduction and adduction pass through the 2nd digit (2nd toe), which differs from the hand, where movements of the fingers are described around an axis that passes through the 3rd digit.

The order of dissection will be as follows: The skin and fat pad on the sole of the foot will be removed. The plantar aponeurosis will be cleaned of superficial fascia, studied, and reflected to expose the first muscle layer of the sole. The dissection will proceed from superficial (inferior) to deep (superior) and each of the four layers of the sole will be dissected.

## Skeletal Anatomy

### *Skeleton of the Plantar Surface of the Foot*

ATLAS 6.61A, 6.63D, 6.67E

1. Refer to FIGURE 6.28.
2. In the articulated foot, identify the seven tarsal bones beginning with the "heel bone," the **calcaneus**.
3. On the posterior superior surface of the calcaneus, identify the roughened region of the **calcaneal tuberosity**.
4. From the calcaneal tuberosity, palpate medially and anteriorly to the shelf-like projection of the **sustentaculum tali**.
5. Identify the **talus** superior to the calcaneus and observe that in an articulated skeleton the superior aspect of the talus articulates with the inferior aspect of the tibia.
6. Anterior to the talus medially, identify the "boat-shaped" **navicular** bone.
7. Observe that on the medial aspect of the foot, the navicular articulates on its anterior surface with the three **cuneiform bones**: first (medial), second (intermediate, middle), and third (lateral).
8. On the lateral aspect of the foot, lateral to the lateral cuneiform and navicular, identify the last of the tarsal bones, the **cuboid**.
9. Observe that the cuboid articulates with the anterior aspect of the calcaneus on the lateral aspect of the foot.

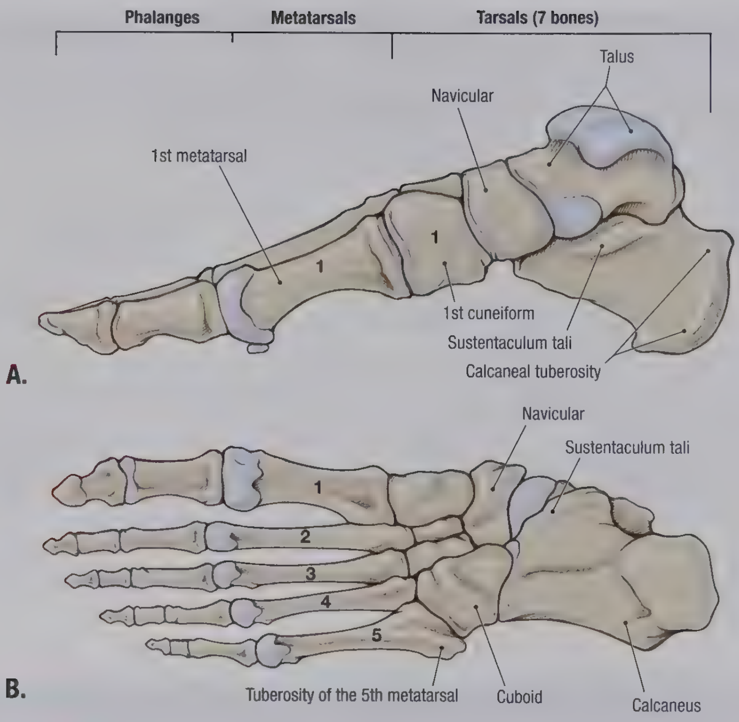


FIGURE 6.28 ● Skeleton of the right foot. **A.** Medial view. **B.** Inferior (plantar) view.

10. Distal to the tarsal bones, identify the five **metatarsal bones** beginning with the 1st metatarsal on the medial aspect of the foot and ending with the 5th metatarsal on the lateral aspect of the foot.
11. Identify the **tuberosity of the 5th metatarsal bone** and observe that it extends laterally past the cuboid and serves as a site of muscle attachment.
12. Distal to the metatarsals, identify the fourteen **phalanges**. Observe that the 1st toe has only two phalanges, whereas the other toes each have three phalanges.

# Dissection Instructions

## Skin Incisions of the Sole of the Foot

ATLAS 6.68A, 6.73B; VIDEO 6.9.1

***Dissection Note:*** Perform the following dissection sequence bilaterally.

1. Refer to FIGURE 6.29.
2. Place the cadaver in the prone position.
3. Make a midline incision extending from the heel (I) to the base of the 2nd digit (M).
4. Make a horizontal incision arching from the base of the 1st digit to the base of the 5th digit (H to H).
5. Remove the skin beginning at the midline incision and working toward the edges of the foot. Observe that the skin is thick over the heel and over the heads of the metatarsal bones but is thinner on the toes and the instep.
6. Remove the skin on the plantar surface of the toes on at least two digits by making a midline incision down the digit to its distal extent (P).

## Plantar Aponeurosis and Cutaneous Nerves

ATLAS 6.68A, 6.73B; VIDEO 6.9.2

1. Refer to FIGURE 6.30.
2. Observe that the plantar fascia over the medial and lateral sides of the sole of the foot is thin, whereas in the center, it is thickened to form the **plantar aponeurosis.**
3. Use a scalpel blade to scrape the superficial fascia off the plantar aponeurosis.
4. Observe that the plantar aponeurosis is attached to the calcaneus posteriorly and that it divides distally into five bands as **digital slips**, one to each toe. *Note that the five bands are joined by the superficial transverse metatarsal ligaments.*
5. Use a probe to elevate the plantar aponeurosis longitudinally. To fully elevate the plantar aponeurosis, it may be necessary to carefully cut along its lateral edges with a scalpel. Do not cut too deeply.

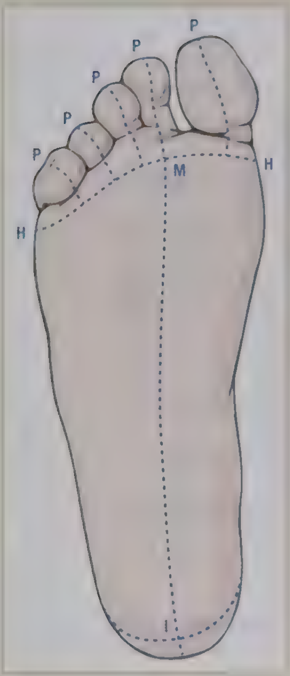


FIGURE 6.29 ■ Skin incisions of the sole of the right foot. Inferior view.

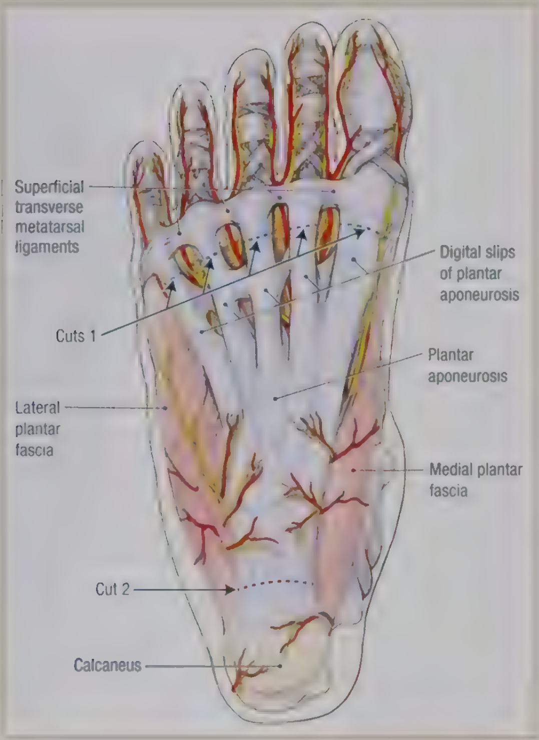


FIGURE 6.30 ■ Sole of the right foot. Inferior view.

6. Make a transverse cut through the plantar aponeurosis distally in the anterior one-third of the foot (**Cuts 1**).
7. Reflect the plantar aponeurosis proximally toward the calcaneus.
8. Observe that tough bands of connective tissue attach the plantar aponeurosis to the metatarsal bones. Use a scalpel to cut these bands and release the plantar aponeurosis from the underlying structures.
9. Remove the plantar aponeurosis from the sole of one foot by making a horizontal incision near its attachment to the calcaneus (**Cut 2**).

## First Layer of the Sole of the Foot

ATLAS 6.74; VIDEO 6.9.3

***Dissection Note:*** Perform the following dissection sequence bilaterally.

1. Refer to FIGURE 6.31.
2. Identify the **flexor digitorum brevis muscle**, which lies in the center of the foot immediately deep to the plantar aponeurosis.
3. Trace the flexor digitorum brevis tendons toward their distal attachments removing remnants of the plantar aponeurosis as necessary.
4. On the plantar surface of at least two digits, make a vertical incision along the length of the toe through the synovial sheaths overlying the flexor digitorum brevis tendons (**Cut 3**) making an effort to not cut too deeply.
5. Spread open the synovial sheath to expose the "Y" shaped tendinous attachment of the flexor digitorum brevis to the middle phalanx.
6. Identify the **abductor hallucis muscle** on the medial side of the flexor digitorum brevis muscle and use blunt dissection to follow its tendon toward its distal attachment on the great toe.
7. Identify the **abductor digiti minimi muscle** on the lateral side of the flexor digitorum brevis muscle and use blunt dissection to follow its tendon toward its distal attachment on the 5th (small) toe.
8. Follow the medial plantar artery and nerve until the branching point into the **common plantar digital arteries**.
9. Clean the common plantar digital arteries and identify the **proper plantar digital arteries** branching from them in the web of the toes. Observe that branches from the medial plantar artery supply the first three toes and the medial aspect of the 4th digit.
10. Observe that the **common** and **proper plantar digital nerves** parallel the vessels to supply the peripheral aspects of each toe and that they lie between the tendons of the muscles of the first layer of the foot.

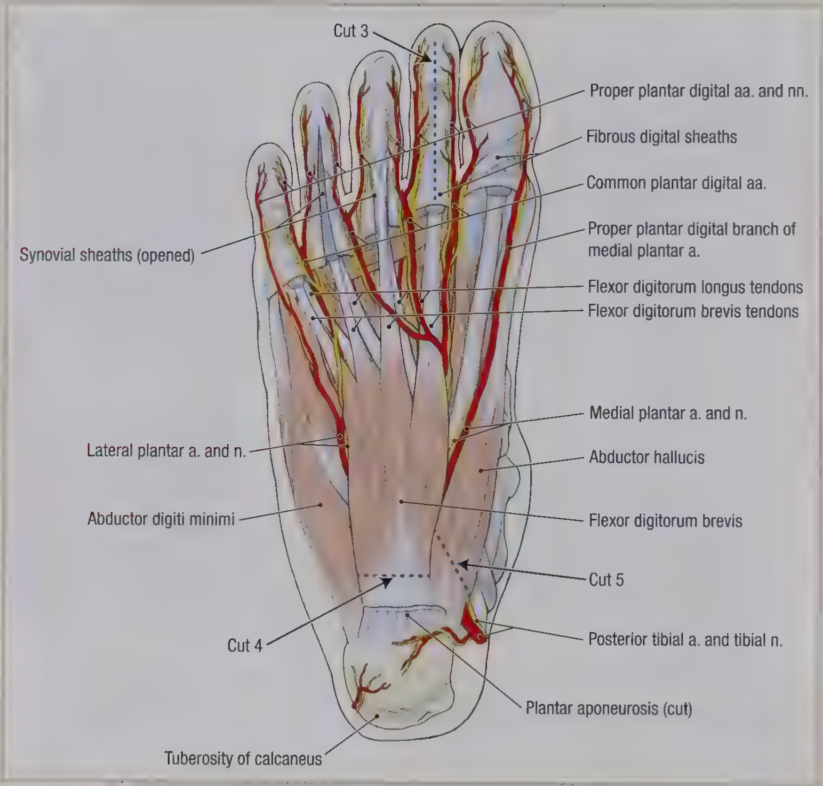

Cut 3
Proper plantar digital aa. and nn.
Fibrous digital sheaths
Common plantar digital aa.
Proper plantar digital branch of medial plantar a.
Synovial sheaths (opened)
Flexor digitorum longus tendons
Flexor digitorum brevis tendons
Medial plantar a. and n.
Lateral plantar a. and n.
Abductor hallucis
Abductor digiti minimi
Flexor digitorum brevis
Cut 5
Cut 4
Posterior tibial a. and tibial n.
Plantar aponeurosis (cut)
Tuberosity of calcaneus

FIGURE 6.31 ● First muscle layer of the sole of the right foot. Inferior view.

11. Review the attachments, actions, and innervation of the muscles of the first layer of the foot (see **TABLE 6.8**).
12. Use scissors to transect the flexor digitorum brevis muscle close to the calcaneus (**Cut 4**) and reflect the muscle distally.
13. Push a probe deep to the abductor hallucis muscle along the course of the posterior tibial artery and tibial nerve.
14. Cut the abductor hallucis muscle over the probe (**Cut 5**) and reflect the muscle distally.

## Second Layer of the Sole of the Foot

ATLAS 6.75; VIDEO 6.9.4

***Dissection Note:*** Perform the following deep dissection steps for the second through fourth layers of the sole on only one foot.

1. Refer to FIGURE 6.32.
2. Use blunt dissection to follow the posterior tibial artery and tibial nerve into the sole of the foot and identify the **medial** and **lateral plantar nerves** and **arteries**.
3. Identify the **quadratus plantae muscle** deep to the flexor digitorum brevis muscle.
4. Use blunt dissection to isolate the **flexor digitorum longus tendons** in the sole of the foot.
5. Observe that the four tendons of the flexor digitorum longus pass through the tendons of the flexor digitorum brevis muscle near the proximal interphalangeal joints to reach the distal phalanges.
6. Observe that four **lumbrical muscles** arise from the tendons of the flexor digitorum longus muscle.
7. Observe that the first lumbrical arises from the medial surface of the first tendon of flexor digitorum longus, whereas the remaining three arise between two adjacent tendons.
8. Review the attachments, actions, and innervation of the muscles of the second layer of the foot (see **TABLE 6.8**).
9. Use scissors to transect the flexor digitorum longus tendon where it is joined by the quadratus plantae muscle (**Cut 6**) and reflect the tendons distally along with the attached lumbrical muscles.

***Dissection Note:*** To reflect the tendons of the muscles in the second layer of the foot, it may be necessary to also transect the medial plantar artery and nerve and reflect them distally toward the toes.

10. Transect the abductor digiti minimi muscle near its attachment to the calcaneus and reflect it distally (**Cut 7**).

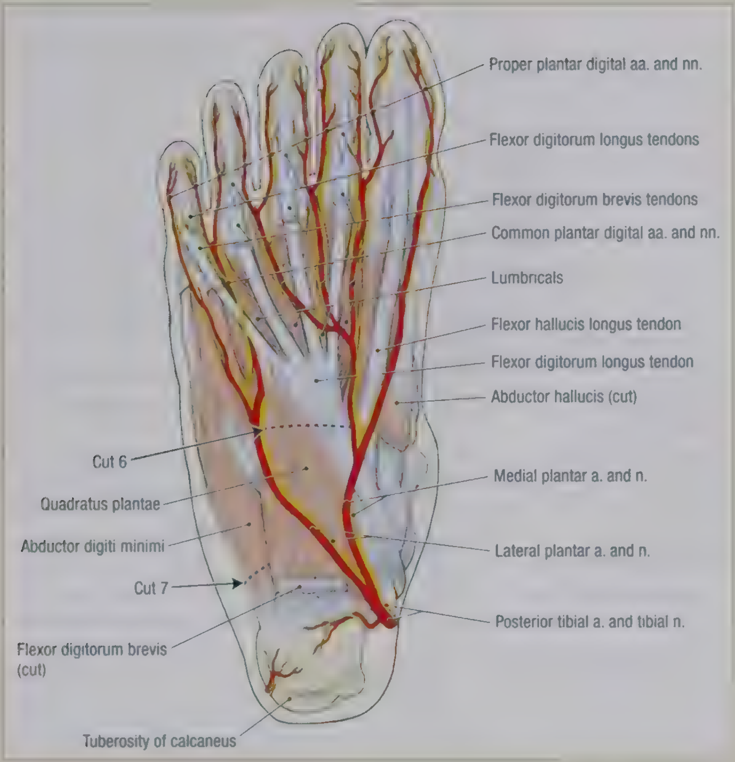

Proper plantar digital aa. and nn.
Flexor digitorum longus tendons
Flexor digitorum brevis tendons
Common plantar digital aa. and nn.
Lumbricals
Flexor hallucis longus tendon
Flexor digitorum longus tendon
Abductor hallucis (cut)
Cut 6
Medial plantar a. and n.
Quadratus plantae
Abductor digiti minimi
Lateral plantar a. and n.
Cut 7
Posterior tibial a. and tibial n.
Flexor digitorum brevis (cut)
Tuberosity of calcaneus

FIGURE 6.32 ● Second muscle layer of the sole of the right foot. Inferior view.

## Third Layer of the Sole of the Foot

ATLAS 6.76; VIDEO 6.9.5

1. Refer to FIGURE 6.33.
2. Identify and clean the **flexor hallucis brevis muscle** coursing along the deep surface of the **flexor hallucis longus tendon** near the distal attachment site of the **tibialis posterior tendon**.
3. Observe that the flexor hallucis brevis is composed of a **medial head** and a **lateral head** and that each head has its own tendon. *Note that a sesamoid bone is found in each of the tendons.*
4. Observe that the tendon of the flexor hallucis longus muscle lies superficial to the flexor hallucis brevis is positioned between the sesamoid bones in the two flexor hallucis brevis tendons and attaches to the base of the distal phalanx of the great toe.
5. In the central compartment of the foot, identify and clean the **adductor hallucis muscle**.
6. Observe that the adductor hallucis muscle has a **transverse head** and an **oblique head**, which both attach to the lateral side of the base of the proximal phalanx of the great toe.
7. On the lateral aspect of the foot, identify and clean the **flexor digiti minimi brevis muscle**.
8. Observe the close proximity of the flexor digiti minimi muscle to the distal attachment of the **fibularis brevis tendon** and the path of the **fibularis longus tendon**.
9. Review the attachments, actions, and innervation of the muscles of the third layer of the foot (see **TABLE 6.8**).
10. Use blunt dissection to trace the **lateral plantar artery** distally and observe that at the level of the base of the metatarsal bones, it splits into **superficial** and **deep branches**.
11. Trace the deep branch medially and observe that it turns sharply to form the **plantar arch**.
12. Follow the plantar arch medially until it passes deep to the oblique head of the adductor hallucis muscle. *Note that the medial end of the plantar arch is formed by the deep plantar artery, a branch of the dorsalis pedis artery.*
13. Identify the **plantar metatarsal arteries** arising from the plantar arch, which course between the muscles in the third and fourth muscular layers.

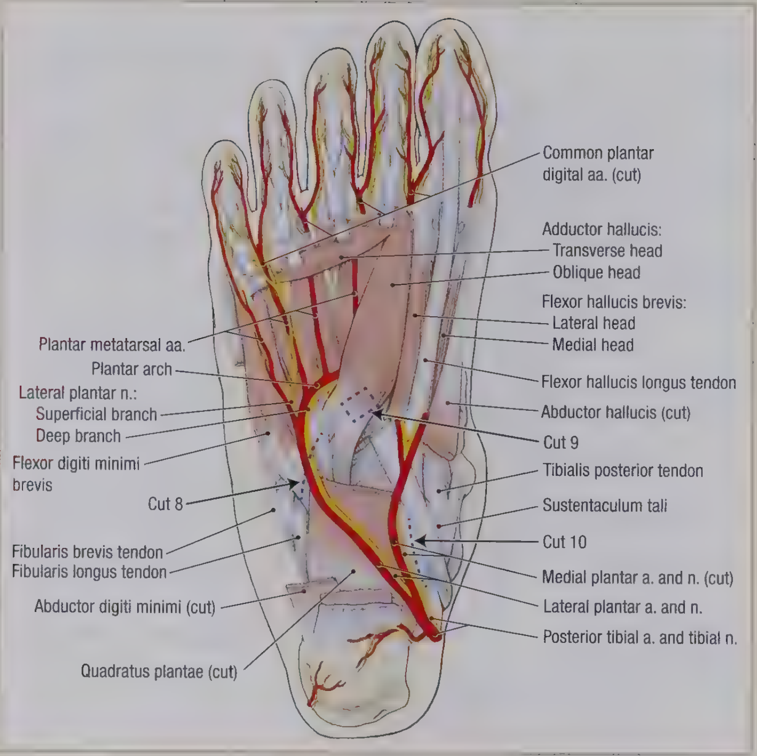

Common plantar digital aa. (cut)
Adductor hallucis:
Transverse head
Oblique head
Flexor hallucis brevis:
Lateral head
Medial head
Flexor hallucis longus tendon
Abductor hallucis (cut)
Cut 9
Tibialis posterior tendon
Sustentaculum tali
Cut 10
Medial plantar a. and n. (cut)
Lateral plantar a. and n.
Posterior tibial a. and tibial n.
Plantar metatarsal aa.
Plantar arch
Lateral plantar n.:
Superficial branch
Deep branch
Flexor digiti minimi brevis
Cut 8
Fibularis brevis tendon
Fibularis longus tendon
Abductor digiti minimi (cut)
Quadratus plantae (cut)

FIGURE 6.33 ● Third muscle layer of the sole of the right foot. Inferior view.

14. Follow the plantar metatarsal arteries distally and observe that they anastomose with the more superficially located common plantar digital arteries.
15. Follow the **lateral plantar nerve** to the point at which it splits into **superficial** and **deep branches** and observe that its branches supply aspects of the 4th digit laterally and the 5th digit.

## Fourth Layer of the Sole of the Foot

ATLAS 6.77; VIDEO 6.9.6

1. Refer to FIGURE 6.33.
2. Locate the **fibularis longus tendon** posterior to the lateral malleolus and insert a probe along its superficial surface deep to the flexor digiti minimi brevis muscle near the cut edge of the abductor digiti minimi muscle.
3. Transect the flexor digiti minimi brevis muscle over the probe and reflect it distally (**Cut 8**).
4. Follow the fibularis longus tendon into the sole of the foot and observe that it turns deeply around the lateral surface of the cuboid bone.
5. Insert a probe along the superficial surface of the fibularis longus tendon (into its tendon sheath) and gently push the probe medially across the sole of the foot. Wiggle the probe so that you can see where the tip is and note that the fibularis longus tendon crosses the sole of the foot at its deepest plane.
6. To better visualize the path of the fibularis longus tendon, cut a small window into the tendon sheath (**Cut 9**) and then gently pull on the tendon near the ankle to view it moving through the cut window.
7. On the medial side of the foot, follow the **tibialis posterior tendon** distally and verify that it has a broad distal attachment on the navicular bone; all three cuneiform bones; and the bases of the 2nd, 3rd, and 4th metatarsal bones.
8. Identify the **flexor hallucis longus muscle** in the posterior compartment of the leg. Follow its tendon distally until it disappears into an osseofibrous tunnel at the medial side of the ankle.
9. Push a probe into the osseofibrous tunnel superficial to the flexor hallucis longus tendon and open the tunnel by cutting down to the probe with a scalpel (**Cut 10**).

10. Lift the tendon of the flexor hallucis longus muscle with a probe and verify that it crosses the inferior surface of the **sustentaculum tali**. *Note that the sustentaculum tali acts as a pulley to change the direction of force of the flexor hallucis longus muscle.*
11. Refer to FIGURE 6.34.
12. Observe that the **interosseous muscles** are located superior (deep) to the plantar arch.
13. Make an effort to identify but not isolate the four bipennate **Dorsal interosseous muscles**, which are **AB**ductors **(DAB)**, and the three unipennate **Plantar interosseous muscles**, which are **AD**ductors **(PAD)**, of the toes.

***Dissection Note:*** Recall that the reference axis for abduction and adduction of the foot passes through the 2nd metatarsal and toe.

14. Review the attachments, actions, and innervation of the muscles of the fourth layer of the foot (see **TABLE 6.8**).

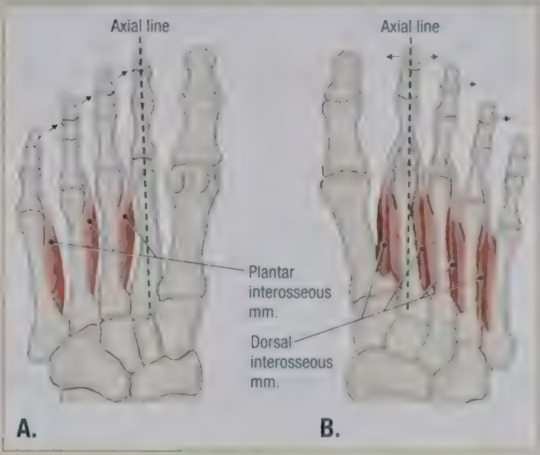


FIGURE 6.34 ● Fourth muscle layer of the sole of the right foot, the interosseous muscles. **A.** Plantar view. **B.** Dorsal view.

## Dissection Follow-up

1. Review the attachments and action of each muscle in the four layers of the foot as shown in **TABLE 6.8**.
2. Follow the posterior tibial artery from its origin in the leg to its bifurcation in the sole of the foot and review the distribution of the medial and lateral plantar arteries.
3. Review the connection between the deep plantar arch and the deep plantar branch of the dorsalis pedis artery.
4. Trace the course of the tibial nerve from the popliteal fossa to the medial side of the ankle. Follow its two branches in the sole of the foot (medial and lateral plantar nerves).
5. Trace the pathway of the medial and lateral plantar nerves in your dissected cadaver and review their motor and sensory functions.
6. Replace the structures of the four layers of the sole of the foot into their correct anatomical positions.

**TABLE 6.8 Muscles of the Sole of Foot**

FIRST LAYER

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Flexor digitorum brevis | Calcaneal tuberosity and plantar aponeurosis | Middle phalanges of the lateral four toes | Flexes toes 2–5 | Medial plantar n. |
| Abductor hallucis | Medial process of tuberosity of calcaneus, flexor retinaculum, and plantar aponeurosis | Medial side of base of proximal phalanx of 1st digit | Abducts and flexes 1st digit | |
| Abductor digiti minimi | Medial and lateral processes of tuberosity of calcaneus, plantar aponeurosis, and intermuscular septa | Lateral side of base of proximal phalanx of 5th digit | Abducts and flexes 5th digit | Lateral plantar n. |

SECOND LAYER

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Quadratus plantae | Medial surface and lateral margin of plantar surface of calcaneus | Posterolateral margin of tendon of flexor digitorum longus | Flexes lateral four digits | Lateral plantar n. |
| Lumbricals | Tendons of flexor digitorum longus | Medial aspect of extensor expansion of lateral four digits | Flexes proximal phalanges and extends middle and distal phalanges of digits 2–4 | Medial plantar n. (first)<br>Lateral plantar n. (second to fourth) |

THIRD LAYER

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Flexor hallucis brevis | Plantar surfaces of cuboid and lateral cuneiforms | Both sides of base of proximal phalanx of 1st digit | Flexes proximal phalanx of 1st digit | Medial plantar n. |
| Adductor hallucis | Bases of metatarsals 2–4 (oblique head), plantar ligaments of MTP (transverse head) | Lateral side of base of proximal phalanx of 1st digit | Adducts 1st digit | Deep branch of lateral plantar n. |
| Flexor digiti minimi | Base of 5th metatarsal | Base of proximal phalanx of 5th digit | Flexes proximal phalanx of 5th digit | Superficial branch of lateral plantar n. |

FOURTH LAYER

| *Muscle* | *Proximal Attachments* | *Distal Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Plantar interossei | Plantar surface of metatarsals 3–5 | Medial sides of bases of phalanges of digits 3–5 | Adducts digits 3–5 and flexes MTP joints | Lateral plantar n. |
| Dorsal interossei | Adjacent sides of metatarsals 1–5 | Medial side of proximal phalanx of 2nd digit (first), lateral sides of proximal phalanx of digits 2–4 (second to fourth) | Abducts digits 2–4 and flexes MTP joints | |

Abbreviations: MTP, metatarsophalangeal joint; n., nerve.

# JOINTS OF THE LOWER LIMB

## Dissection Overview

In order to dissect the joints in the lower limb, it will be necessary to reflect or remove a majority of the surrounding muscles. Because the joint dissections will make it difficult to review key muscular relationships later, it is recommended to limit the joint dissections to one lower limb and to keep the soft tissue structures of the other limb intact for review purposes. Alternatively, if enough cadaveric specimens are available in the lab, perform only select dissections on each limb and alternate the dissections performed on each cadaver. While removing the muscles of the selected lower limb, take advantage of this opportunity to review the attachments, actions, and innervation of each muscle as it is removed.

The order of dissection will be as follows: The hip will be dissected. The knee joint will be dissected. The ankle joint will be dissected. The intermetatarsal joints, which are responsible for inversion and eversion, will be studied.

## Dissection Instructions

### Hip Joint

ATLAS 6.36, 6.37, 6.40D; VIDEO 6.10.1

***Dissection Note:*** Perform the following dissection sequence on only one lower limb.

1. Refer back to FIGURE 6.12 and FIGURE 6.13 and to FIGURE 6.35.
2. On the specimen, identify the three bones that form the acetabulum: the **ilium**, **ischium**, and **pubis**.
3. Detach the sartorius muscle from its superior attachment to the ASIS and reflect the muscle inferiorly.
4. Detach the rectus femoris muscle from its superior attachment to the AIIS and reflect the muscle inferiorly.
5. Remove the **pectineus muscle** completely from the dissection field to expose the anterior aspect of the joint capsule of the hip.
6. Cut the tendon of the **iliopsoas muscle** close to the lesser trochanter and reflect the muscle superiorly.
7. Identify the ligaments that contribute to the formation of the **fibrous joint capsule**: **iliofemoral ligament**, **ischiofemoral ligament**, and **pubofemoral ligament**.
8. Examine the **iliofemoral ligament** and verify that the distal end is attached to the intertrochanteric line of the femur and that the proximal end is attached to the AIIS and the margin of the acetabulum.
9. Flex and extend the femur and observe that the iliofemoral ligament becomes lax in flexion and taut in extension. *Note that the iliofemoral ligament prevents overextension of the hip joint.*
10. Open the anterior aspect of the **joint capsule** by cutting through the iliofemoral ligament anteriorly and the pubofemoral ligament inferiorly (**Cut 1**).
11. Inside the joint capsule, observe the **cartilage on the articular surface of the head of the femur**. Rotate the femur laterally and observe that you can see more of the articular surface of the head. Rotate the femur medially and observe that the articular surface disappears into the **acetabulum**.
12. Abduct and laterally rotate the femur and identify the **ligament of the head of the femur**.
13. Identify the obturator externus muscle and observe that the obturator externus muscle passes inferior to the neck of the femur.
14. Remove the obturator externus muscle to expose the **pubofemoral ligament** and the **obturator membrane**.
15. Observe that the **obturator artery and nerve** pass through the obturator canal, a gap within the obturator membrane, to supply the medial compartment of the thigh.
16. Insert a probe under the ligament of the head of the femur and cut the ligament with a scalpel over the path of the probe (**Cut 2**).
17. Refer to FIGURE 6.36.
18. Turn the cadaver to the prone position.

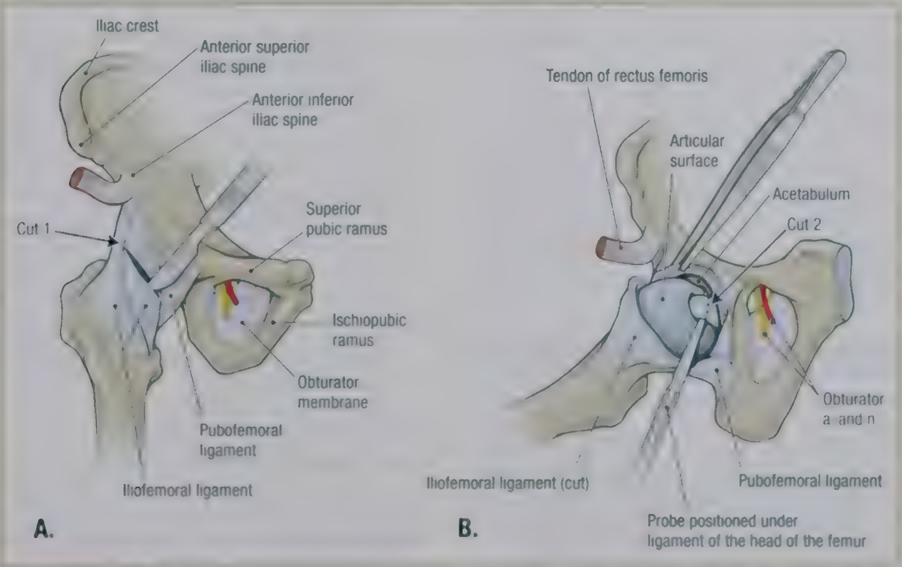

Iliac crest
Anterior superior iliac spine
Anterior inferior iliac spine
Cut 1
Superior pubic ramus
Ischiopubic ramus
Obturator membrane
Pubofemoral ligament
Iliofemoral ligament
A.
Tendon of rectus femoris
Articular surface
Acetabulum
Cut 2
Obturator a. and n.
Iliofemoral ligament (cut)
Pubofemoral ligament
Probe positioned under ligament of the head of the femur
B.

FIGURE 6.35 ■ Opening the anterior surface of the right hip joint capsule. **A.** Initial incision. **B.** Exposed head of femur. Anterior views.

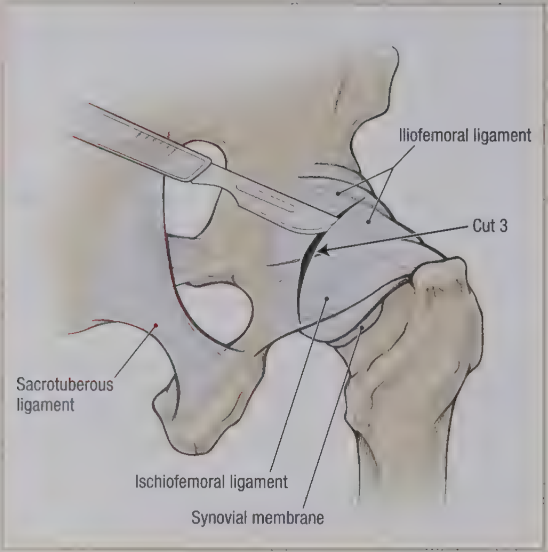


FIGURE 6.36 ● Opening the posterior surface of the right hip joint capsule. Posterior view.

19. Reflect the gluteus maximus muscle laterally.
20. Reflect the gluteus medius and gluteus minimus muscles laterally.
21. Detach the piriformis, superior gemellus, obturator internus, inferior gemellus, and quadratus femoris from their lateral attachments to the femur and reflect the muscles medially.

***Dissection Note:*** To increase visibility of the hip joint posteriorly, completely remove the lateral rotators of the hip from the dissection field.

22. Clean the posterior surface of the **joint capsule**.
23. Identify the **ischiofemoral ligament** coursing from the acetabular margin to the neck of the femur. *Note that the ischiofemoral ligament does not attach to the intertrochanteric crest, which leaves an area where the synovial membrane of the hip joint is exposed.*
24. Extend the femur and observe that the ischiofemoral ligament becomes taut and limits extension of the hip joint.

## CLINICAL CORRELATION

### Neck of the Femur Fracture

ATLAS 6.40

A fracture of the neck of the femur disrupts the blood supply to the head of the femur. If the blood supply (via the artery of the ligament of the head) is insufficient, the head of the femur will become necrotic and need replacing. Necrosis of the femoral head is a common complication in femoral neck fractures particularly in the elderly.

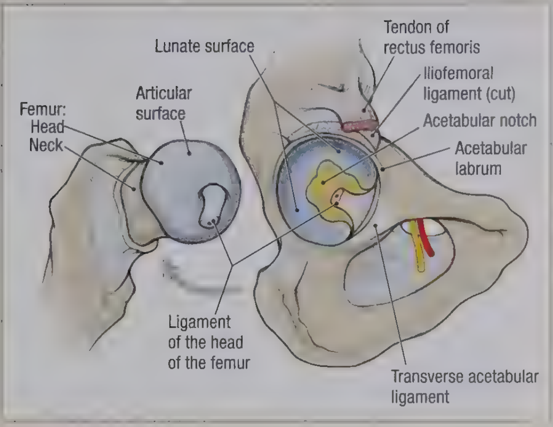


FIGURE 6.37 ● Disarticulated right hip joint. Anterior view.

25. Open the posterior wall of the joint cavity by cutting the joint capsule through the iliofemoral ligament superiorly and the ischiofemoral ligament posteriorly to make a complete circumferential cut with the incision made anteriorly (**Cut 2**).
26. Spread apart the two halves of the now bisected joint capsule and observe the thickness of the joint capsule.
27. Refer to FIGURE 6.37.
28. Return the specimen to the supine position.
29. Rotate the femur laterally until the head of the femur comes out of the acetabulum.
30. Observe that the joint capsule encloses both the **neck** and **head of the femur**.
31. Examine the articular surface of the head of the femur and identify the depression of the **fovea capitis**, the attachment site of the **ligament of the head of the femur**.
32. Observe the cut end of the ligament of the head of the femur and identify the **artery of the ligament of the head of the femur** in the center of the ligament.
33. Identify the **lunate surface** in the acetabulum, the smooth half-moon–shaped articular surface.
34. Identify the **acetabular notch**, a gap in the lunate surface anteriorly around the medial attachment of the **ligament of the head of the femur**.
35. Identify the **transverse acetabular ligament** that bridges the acetabular notch and the **acetabular labrum** that surrounds the rim of the acetabulum deepening the socket.

## Knee Joint Posterior Approach

ATLAS 6.48, 6.51; VIDEO 6.10.2

***Dissection Note:*** Perform the following dissection sequence on the lower limb with the transected medial and lateral heads of the gastrocnemius.

1. Refer to FIGURE 6.38.
2. Turn the cadaver to a prone position.

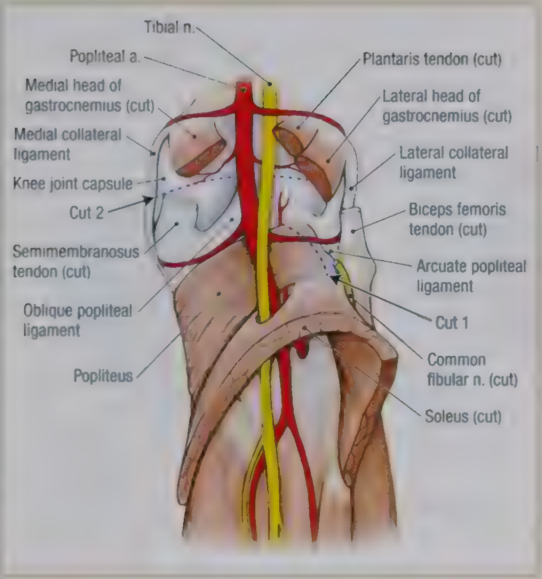

Tibial n.
Popliteal a.
Medial head of gastrocnemius (cut)
Medial collateral ligament
Knee joint capsule
Cut 2
Semimembranosus tendon (cut)
Oblique popliteal ligament
Popliteus
Plantaris tendon (cut)
Lateral head of gastrocnemius (cut)
Lateral collateral ligament
Biceps femoris tendon (cut)
Arcuate popliteal ligament
Cut 1
Common fibular n. (cut)
Soleus (cut)

FIGURE 6.38 ● Right knee. Posterior view.

3. In the cadaver, identify the **medial condyle, lateral condyle**, and **intercondylar fossa** on the distal end of the femur.
4. Identify the **medial** and **lateral condyles** on the proximal end of the tibia.
5. Identify the tendons of the sartorius, gracilis, and semitendinosus muscles attaching at their distal attachments (pes anserinus) on the medial side of the knee. Recall that these three muscles all arise from different compartments of the thigh and thus have different motor innervations, yet all work together to flex the knee and medially rotate the tibia.
6. Elevate the muscles attaching to the pes anserinus and identify the **medial (tibial) collateral ligament (MCL)** of the knee. *Note that the MCL is attached to the medial meniscus through the joint capsule.*
7. On the lateral side of the knee, identify the **tendon of the biceps femoris muscle** close to its distal attachment on the head of the fibula.
8. Identify the **lateral (fibular) collateral ligament (LCL)** of the knee and observe that it is not attached to the external surface of the joint capsule.
9. On the posterior aspect of the knee, observe that the popliteus tendon passes between the lateral collateral ligament and the joint capsule.
10. On the posterior aspect of the knee, identify the **oblique popliteal ligament** that sweeps superiorly and laterally from the tendon of the semimembranosus muscle. *Note that the oblique popliteal ligament reinforces the posterior surface of the knee joint capsule.*
11. If the oblique popliteal tendon is not clearly visible, remove the popliteal vessels, the tibial nerve, and the common fibular nerve from the popliteal fossa.
12. Identify the popliteus muscle and observe the presence of the **arcuate popliteal ligament** that spans the superficial surface of the popliteus tendon. *Note that the popliteus muscle reinforces the posterior wall of the joint capsule.*
13. Cut the popliteus tendon (**Cut 1**) and reflect the muscle inferiorly to expose the posterior surface of the capsule enclosing the knee.
14. Use scissors to make a horizontal incision through the joint capsule (**Cut 2**) and remove the posterior aspect of the joint capsule from the dissection field.
15. Refer to FIGURE 6.39A.
16. From a posterior perspective, identify the cruciate ligaments, which cross each other within the joint capsule.
17. Observe that the **posterior cruciate ligament (PCL)** attaches to the tibia posteriorly and note that the **anterior cruciate ligament (ACL)** attaches to the tibia anteriorly.
18. Identify the **medial** and **lateral menisci**. Observe that the **medial meniscus** is firmly attached to the tibial collateral ligament, while in contrast, the **lateral meniscus** is not attached to the fibular collateral ligament.

**CLINICAL CORRELATION**

### Knee Injuries

ATLAS 6.47, 6.48

Forced abduction and lateral rotation of the leg may result in the simultaneous injury of the MCL, medial meniscus, and ACL, otherwise known as the "unhappy triad". Typically, an unhappy triad injury is caused by a blow to the lateral side of the knee which forces the inner aspect of the knee to rapidly expand, a common injury in contact sports. As the medial meniscus is firmly attached to the MCL, while the lateral meniscus is separated from the LCL by the popliteal tendon, the medial meniscus is injured six to seven times more often than the lateral meniscus.

## Knee Joint Anterior Approach

ATLAS 6.47, 6.49; VIDEO 6.10.3

***Dissection Note:*** Perform the following dissection sequence on the contralateral lower limb to where the posterior knee joint approach was performed.

1. Refer to FIGURE 6.39B and FIGURE 6.39C.
2. On the anterior surface of the knee, identify the tendon of the quadriceps femoris muscle superior to the patella and the **patellar ligament** inferior to the patella.

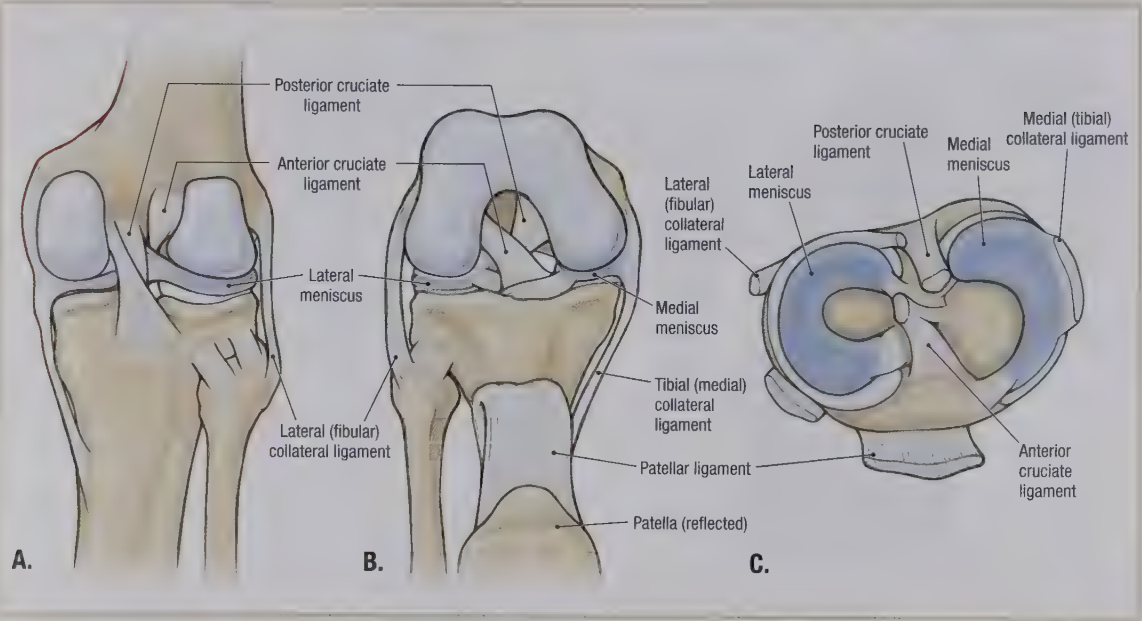

Posterior cruciate ligament
Anterior cruciate ligament
Lateral meniscus
Lateral (fibular) collateral ligament
A.
B.
Lateral (fibular) collateral ligament
Medial meniscus
Tibial (medial) collateral ligament
Patellar ligament
Patella (reflected)
Lateral meniscus
Posterior cruciate ligament
Medial meniscus
Medial (tibial) collateral ligament
Anterior cruciate ligament
C.

FIGURE 6.39 Right knee joint. **A.** Posterior view. **B.** Anterior view. **C.** Superior view.

3. Observe that the quadriceps tendon has **patellar retinacula** that help keep the patella centered in the knee.
4. Make a transverse incision superior to the patella through the quadriceps femoris tendon.
5. Continue the transverse incision around the sides of the knee, stopping short of the medial and lateral collateral ligaments.
6. Reflect the patella and patellar ligament inferiorly and expose the joint cavity anteriorly.
7. Confirm that the femur and the tibia remain attached to each other by **two collateral ligaments** on the periphery of the knee, **two cruciate ligaments** crossing within the joint capsule, and by the oblique and arcuate popliteal ligaments posteriorly.
8. Verify that the cruciate ligaments are located *outside* of the synovial cavity but are *inside* the joint capsule.
9. Verify from an anterior perspective that the cruciate ligaments cross each other to reach the intercondylar eminence of the tibia.
10. Flex the knee and observe that the **ACL** attaches to the tibia anteriorly and that the **PCL** attaches to the tibia posteriorly.
11. Extend the leg and observe that the articular surfaces of the femur and tibia are in maximum contact in an extended position. *Note that when the knee is fully extended, the joint is "locked" in its most stable position, and the ACL is taut and prohibits further extension.*
12. Flex the leg and observe that there is less contact between the articular surfaces of the femur and tibia in a flexed position. Observe that when the knee is flexing, that some rotation occurs in the knee joint.
13. With the knee flexed, pull the tibia forward (anterior drawer test) and observe that the ACL prevents the tibia from being pulled anteriorly. *Note that if the tibia has a large degree of forward movement, it may indicate a ruptured ACL, an important clinical sign.*
14. In the same position, push on the tibia (posterior drawer test) and observe that the PCL prevents the tibia from being pushed posteriorly.
15. Observe from an anterosuperior view that the **medial meniscus** is more "C" shaped, whereas the **lateral meniscus** is more rounded.
16. Confirm from an anterosuperior view that the **MCL** attaches to the medial meniscus, whereas the **LCL** does not attach to the lateral meniscus.

## Ankle Joint

ATLAS 6.79, 6.80, 6.82; VIDEO 6.10.4

***Dissection Note:*** Perform the following dissection sequence on the lower limb where the calcaneal tendon was cut.

1. Refer back to FIGURE 6.23 and FIGURE 6.27.
2. On the distal end of the fibula, identify the **lateral malleolus**.

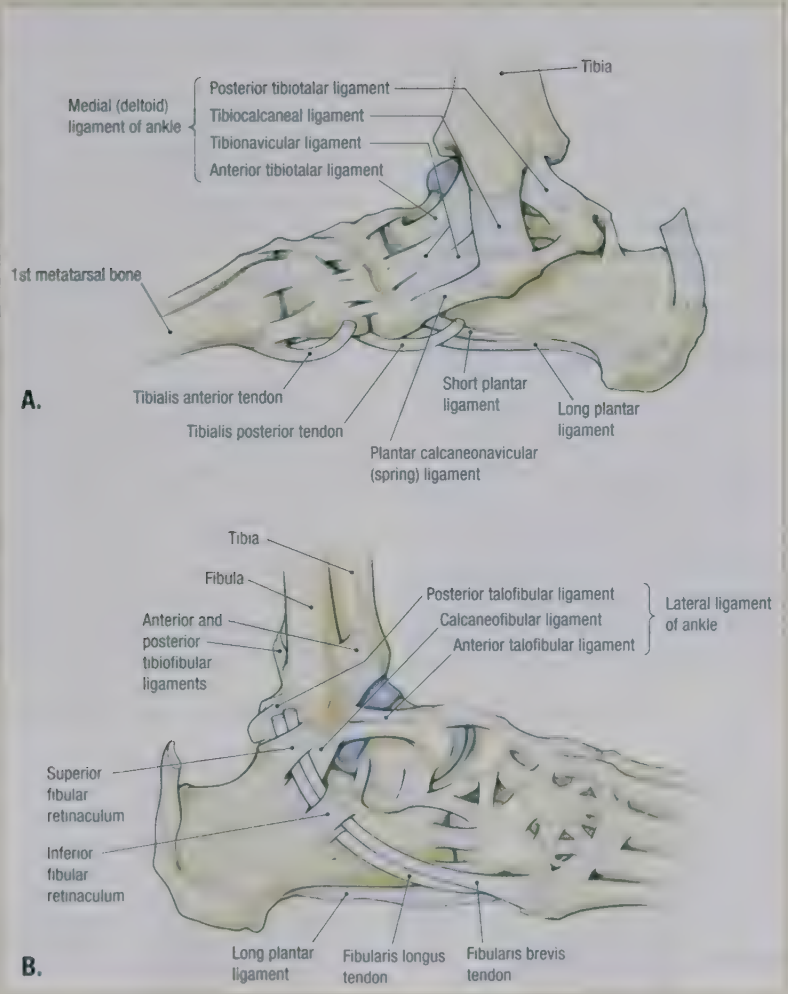

Tibia
Medial (deltoid) ligament of ankle
Posterior tibiotalar ligament
Tibiocalcaneal ligament
Tibionavicular ligament
Anterior tibiotalar ligament
1st metatarsal bone
A.
Tibialis anterior tendon
Tibialis posterior tendon
Short plantar ligament
Long plantar ligament
Plantar calcaneonavicular (spring) ligament
Tibia
Fibula
Anterior and posterior tibiofibular ligaments
Posterior talofibular ligament
Calcaneofibular ligament
Anterior talofibular ligament
Lateral ligament of ankle
Superior fibular retinaculum
Inferior fibular retinaculum
B.
Long plantar ligament
Fibularis longus tendon
Fibularis brevis tendon

FIGURE 6.40 ● Right ankle joint. **A.** Medial view. **B.** Lateral view.

3. On the distal end of the tibia, identify the **medial malleolus**.
4. On the medial aspect of the ankle joint, cut and reflect the flexor digitorum longus muscle.

***Dissection Note:*** When cutting the tendons around the ankle, leave approximately 2 cm of each tendon attached to their respective distal attachments on the skeleton of the foot and reflect the remaining portion of the tendon and muscle away from the ankle to increase exposure of the underlying ligaments.

5. Retract the tendon of the tibialis posterior muscle anteriorly but do not cut it.
6. Cut and reflect the tendons, vessels, and nerves that cross the anterior aspect of one ankle joint.
7. Refer to FIGURE 6.40.
8. On the medial side of the ankle, clean and define the **medial (deltoid) ligament of the ankle**.
9. Observe that the deltoid ligament has four parts that are named according to their skeletal attachments. From anterior to posterior, identify the **anterior tibiotalar ligament**, the **tibionavicular ligament**, the **tibiocalcaneal ligament**, and the **posterior tibiotalar ligament**.

10. On the lateral side of the ankle, make a vertical incision through the superior and inferior fibular retinacula and retract the tendons of the fibularis longus and fibularis brevis muscles anteriorly.
11. Clean and define the **lateral ligament of the ankle**.
12. Observe that the lateral ligament of the ankle has three parts that are named according to their skeletal attachments. From anterior to posterior, identify the **anterior talofibular ligament**, the **calcaneofibular ligament**, and the **posterior talofibular ligament**.
13. Dorsiflex and plantarflex the ankle joint and observe that these are the primary actions of the ankle joint.

CLINICAL CORRELATION

### Ankle Injuries

ATLAS 6.82

The ankle joint is the most frequently injured major joint in the body. The lateral ligament of the ankle is injured when the foot is forcefully inverted resulting in an ankle sprain with swelling around the lateral malleolus. In severe cases, the calcaneofibular and anterior talofibular ligaments are torn and the inferior tip of the lateral malleolus may be avulsed (pulled off).

## Joints of Inversion and Eversion

ATLAS 6.78, 6.91A, 6.91B; VIDEO 6.10.5

***Dissection Note:*** Perform the following dissection sequence on the lower limb where the deep dissection of the foot was performed.

1. Refer to FIGURE 6.41.
2. With one hand, immobilize the ankle joint by holding the talus stationary between the tibia and fibula and use the other hand to invert and evert the foot. Observe that during inversion and eversion, the talus remains fixed in the ankle joint and the foot rotates about the inferior surface of the talus (subtalar joint) and anterior surface of the talus (talonavicular and talocuboid joints).
3. Stabilize the ankle and make an effort to produce **eversion** by pulling on the tendons of the fibularis longus and fibularis brevis muscles.
4. Stabilize the ankle and make an effort to produce **inversion** by simultaneously pulling on the tendons of the tibialis anterior and tibialis posterior muscles.
5. Observe that the movements of inversion and eversion occur at the **transverse tarsal joint** (calcaneocuboid and talonavicular joints) and the **subtalar joint**.

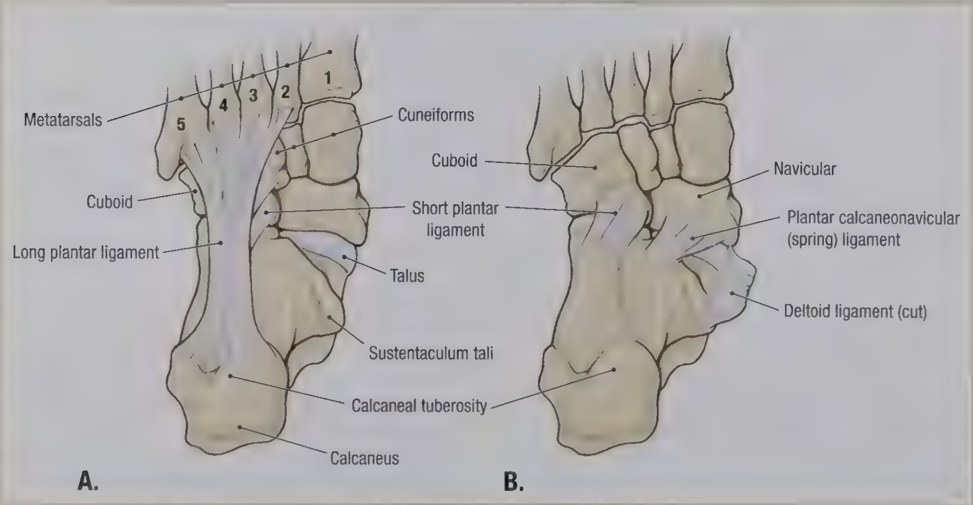


FIGURE 6.41 ■ A. Long plantar ligament. B. Short plantar and spring ligaments. Inferior views.

6. In the sole of the foot where the deep dissection was performed, remove the flexor digitorum brevis and quadratus plantae muscles.
7. Observe that the longitudinal arch of the foot is supported by ligaments that span the tarsal bones.
8. Identify and clean the more superficially located **long planter (calcaneocuboid) ligament** extending from the calcaneal tuberosity to the cuboid bone. *Note that the long plantar ligament is the longest of the tarsal ligaments.*
9. Observe that superficial fibers of the long plantar ligament extend from the cuboid to the base of the 2nd through 5th metatarsals.
10. Deep to the long plantar ligament, identify the **short plantar (calcaneocuboid) ligament** extending from the calcaneus to the cuboid. Observe that the short plantar ligament terminates on the cuboid prior to the groove for the fibularis longus tendon.
11. Cut the tendon of the tibialis posterior muscle near its distal attachment and remove the portion of the tendon crossing inferior to the talus.
12. Identify the **plantar calcaneonavicular (spring) ligament** attaching from the sustentaculum tali of the calcaneus to the plantar surface of the navicular bone.
13. Observe that the spring ligament has three parts that are named according to their skeletal attachments. From medial to lateral, identify the **superomedial ligament**, the **intermedial (medioplantar) ligament**, and the **lateral (inferoplantar) ligament**. *Note that the spring ligament and the tibialis posterior tendon support the head of the talus and the longitudinal arch of the foot and that the spring ligament bears the bulk of the body weight in a normally functioning foot.*

## Dissection Follow-up

1. Review the names of the bones articulating at each joint of the lower limb.
2. Review the movements permitted at each joint of the lower limb.
3. Use the dissected specimen to identify the key ligaments associated with each joint and review their respective points of attachment.
4. Return the reflected muscles of the lower limb back to their anatomical positions.

## CHAPTER 7

# The Head and Neck

**REFERENCES**

ATLAS = *Grant's Atlas of Anatomy*, 15th ed., figure number

VIDEO = *Grant's Dissection Videos*, video sequence number

The study of head and neck anatomy provides a considerable intellectual challenge because the region is packed with small, clinically relevant structures associated with the proximal ends of the respiratory and gastrointestinal systems, the cranial nerves, and the organs of special sense. Dissection of the head and neck provides a special problem in that peripheral structures must be dissected long before their parent structure can be identified. Thus, a full understanding of the region cannot be gained until the final dissection is completed.

The dissection of the head is foremost a dissection of the course and distribution of the cranial nerves and the branches of the external carotid artery. All of the cranial nerves and many blood vessels pass through openings in the skull. Therefore, the skull is an important tool with which to organize the study of the soft tissues of the head and neck. Parts of the skull will be studied as needed, and details will be added as the dissection of the head proceeds.

The neck is a region of transition between the head and the thorax. The major vessels that supply the head and the nerves that innervate the organs within the thorax and abdomen pass through the neck. Portions of several systems are located in the neck: gastrointestinal system (pharynx and esophagus), respiratory system (larynx and trachea), cardiovascular system (major vessels to the head and upper limbs), central nervous system (spinal cord), and endocrine system (thyroid and parathyroid glands). Finally, nerves and vessels to the upper limbs also pass through the inferior part of the neck.

The superficial aspects of the neck (superficial fascia, superficial veins, and cutaneous nerves) will be dissected first. The triangles of the neck will be described, and the anatomy will be discussed within these boundaries. The vascular structures that go to the head as well as the endocrine glands in the neck will then be dissected. The head will begin with superficial then deep dissections of the face. The calvaria will be detached and the brain removed from the cranial cavity. The orbit will then be examined from both a superior and an anterior perspective. The head will either be bisected or reflected to study the anatomy of the nasal and oral cavities. Aspects of the pharynx and larynx will be dissected after the head because they cannot be mobilized until after the head is dissected.

**CLINICAL CORRELATIONS**

During the course of your dissection protocol, you may encounter anatomical variations, clinical conditions, disease processes, or medical devices in your cadaveric donor. The following select clinical correlations will be described in more detail throughout this chapter.

**The Head and Neck**

1. Diaphragmatic Referred Pain, see the **Posterior Triangle of the Neck** sequence. ATLAS 3.67, 4.85
2. Tracheostomy, see the **Muscular Triangle** sequence. ATLAS 8.4
3. Recurrent Laryngeal Nerve Injury, see the **Thyroid and Parathyroid Glands** sequence. ATLAS 3.60B, 8.20
4. Thyroidectomy, see the **Thyroid and Parathyroid Glands** sequence. ATLAS 8.21
5. Thoracic Outlet Syndrome, see the **Subclavian Artery** sequence. ATLAS 3.10B, 8.8G
6. Bell Palsy, see the **Superficial Fascia and the Facial Nerve** sequence. ATLAS 7.16, 9.22C
7. Parotidectomy, see the **Parotid Region** sequence. ATLAS 7.13
8. Scalp Injuries and Infections, see the **Scalp** sequence. ATLAS 7.20
9. Dental Anesthesia, see the **Infratemporal Fossa** sequence. ATLAS 7.50, 7.52

10. Epidural Hemorrhage, see the **Cranial Meninges** sequence. ATLAS 7.21, 7.22B
11. Subdural and Subarachnoid Hemorrhages, see the **Cranial Meninges** sequence. ATLAS 7.22C, 7.22D
12. Cranial Base Fracture, see the **Middle Cranial Fossa** sequence. ATLAS 7.30, 7.34
13. Tarsal Gland Cysts, see the **Eyelid and Lacrimal Apparatus** sequence. ATLAS 7.39C
14. Cavernous Sinus Thrombosis, see the **Contents of the Orbit** sequence. ATLAS 7.44B
15. Tonsillectomy and Adenoids, see the **Internal Aspect of the Pharynx** sequence. ATLAS 8.30
16. Pituitary Tumor Removal, see the **Lateral Wall of the Nasal Cavity** sequence. ATLAS 7.7B, 7.73
17. Maxillary Sinus Infection, see the **Lateral Wall of the Nasal Cavity** sequence. ATLAS 7.77
18. Carotid Endarterectomy and Hypoglossal Nerve Injury, see the **Sublingual Region** sequence. ATLAS 8.16
19. Laryngospasm, see the **Interior of the Larynx** sequence. ATLAS 8.37
20. Otitis Media, see the **Walls of the Tympanic Cavity** sequence. ATLAS 7.85

# SUPERFICIAL NECK

## Dissection Overview

The neck is surrounded by superficial and deep fascial layers, with the deep (investing) layer enclosing the more superficially located muscles as shown in FIGURE 7.1. Deep to the investing fascia the neck may be subdivided into anterior and posterior parts. The larger posterior part contains the cervical vertebral column and associated muscles and is surrounded by prevertebral fascia. The smaller anterior part of the neck contains the cervical viscera and is surrounded by pretracheal fascia. Posteriorly, the pretracheal fascia becomes the buccopharyngeal fascia anterior to the point of separation between the prevertebral and pretracheal fasciae. The point of separation between the pretracheal and prevertebral fasciae is the retropharyngeal space, a potential space subdivided by the alar fascia, a sheet of connective tissue connecting bilaterally to the carotid sheaths. The posterior aspect of the subdivided retropharyngeal space is often referred to as the "danger space" because infections from the head and neck can spread into this space posterior to the alar fascia and pass inferiorly into the posterior mediastinum.

The order of dissection will be as follows: The skin will be removed from the anterior and lateral surfaces of the neck. The platysma muscle will be studied and reflected. The external jugular vein will be identified. Several cutaneous branches of the cervical plexus (great auricular nerve, lesser occipital nerve, transverse cervical nerve, and supraclavicular nerves) will be dissected. The accessory nerve (CN XI) will be identified and followed from the sternocleidomastoid muscle (SCM) to the trapezius muscle.

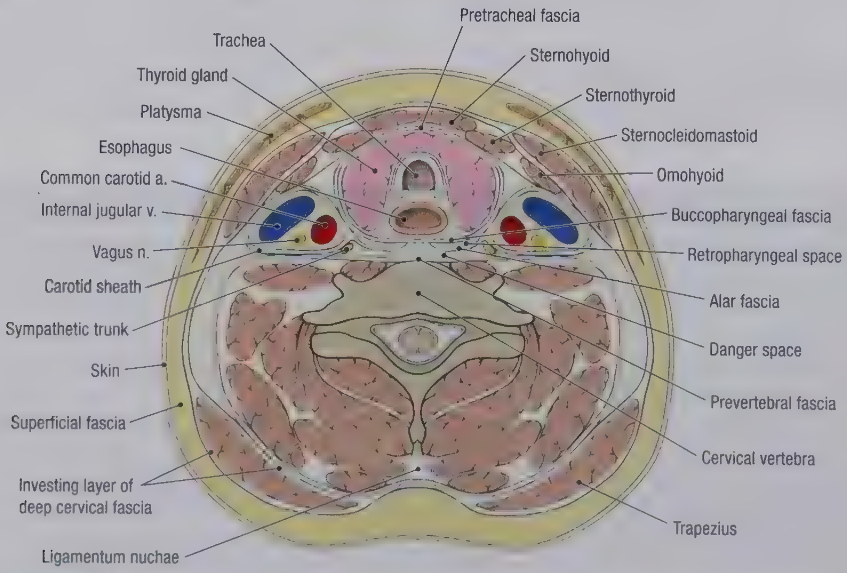

Pretracheal fascia
Trachea
Sternohyoid
Thyroid gland
Sternothyroid
Platysma
Sternocleidomastoid
Esophagus
Omohyoid
Common carotid a.
Internal jugular v.
Buccopharyngeal fascia
Vagus n.
Retropharyngeal space
Carotid sheath
Alar fascia
Sympathetic trunk
Danger space
Skin
Prevertebral fascia
Superficial fascia
Cervical vertebra
Investing layer of deep cervical fascia
Trapezius
Ligamentum nuchae

FIGURE 7.1 ■ Transverse section through the neck at the level of thyroid gland. Inferior view.

## Skeletal Anatomy

Refer to a skeleton or disarticulated cervical vertebrae to identify the following skeletal features.

### *Cervical Vertebrae*

ATLAS 8.5E, 8.5F

1. Refer back to FIGURE 1.11 and to FIGURE 7.2.
2. Observe that cervical vertebrae have small vertebral bodies, relatively large vertebral foramina, **bifid spinous processes**, and transverse processes that contain a **transverse foramen (foramen transversarium)**.
3. On the isolated **atlas (C1)**, identify the **posterior tubercle** at the midpoint of the **posterior arch**. Recall that unlike the other cervical vertebrae, the atlas does not have a body but rather has an **anterior arch and tubercle**.
4. On the superior aspect of the transverse process of C1, identify the groove for the vertebral artery, a smooth depression directed posteromedially along the posterior arch.
5. On the isolated **axis (C2)**, identify the **dens (odontoid process)**, a "toothlike" process extending superiorly from its vertebral body. *Note that the dens is the embryological remnant of the vertebral body of C1, which has fused with the vertebral body of C2.*
6. On the posterior aspect of C2, identify the bifid **spinous process** between the two **laminae**.
7. On **vertebrae C3–C7**, identify the **body**, the **transverse processes** with the associated **transverse foramina**, the laminae, and the **spinous process** of each vertebra.
8. On the articulated skeleton, observe that C7 has the longest cervical spinous process **(vertebra prominens)**.

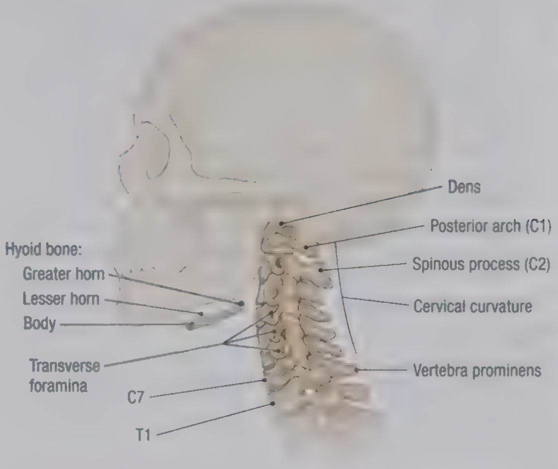


FIGURE 7.2 ● Cervical vertebrae. Left lateral view.

### *Hyoid Bone*

ATLAS 8.5A, 8.5C, 8.5D

1. Refer to FIGURE 7.2.
2. On an articulated skeleton, observe that the **hyoid bone** is the only bone in the body that does not directly articulate with another bone.
3. On an isolated hyoid bone, identify the large bilateral prominences of the **greater horns** projecting posteriorly from the centrally located **body**.
4. Identify the shorter **lesser horns** of the hyoid projecting superiorly near the junction of the greater horns and the body.

## Surface Anatomy

The surface anatomy of the neck may be studied on a living subject or on a cadaver. On the cadaver, note that fixation of tissue during embalming may make it difficult to distinguish bone from well-preserved soft tissues in some specimens.

### *Cervical Triangles*

ATLAS 8.3B, 8.4A, 8.6

1. Refer to FIGURE 7.3.
2. Place the cadaver in the supine position.
3. Palpate the large diagonally oriented **SCM** on the anterolateral aspect of the neck.
4. Follow the SCM superiorly to its superior attachment and palpate the **mastoid process** on the base of the skull posterior to the ear.
5. Follow the SCM inferiorly to its two inferior attachments and palpate the **sternal end of the clavicle** and the **manubrium of the sternum**.

6. Palpate along the lateral aspect of the neck for the anterior border of the **trapezius muscle**.
7. Observe that the **posterior triangle of the neck** is bounded **anteriorly** by the posterior border of the SCM, **posteriorly** by the superior border of the trapezius muscle, and **inferiorly** by the middle one-third of the clavicle. *Note that the posterior triangle of the neck has a superficial boundary (roof) formed by the investing layer of the deep cervical fascia, and a deep boundary (floor) formed by the muscles of the neck covered by prevertebral fascia.*
8. Observe that the **anterior triangle of the neck** is bounded **medially** by the median plane of the neck, **laterally** by the anterior border of the SCM, and **superiorly** by the inferior border of the mandible. *Note that the anterior triangle has a superficial boundary (roof) formed by the investing layer of the deep cervical fascia and a deep boundary (floor) formed by the larynx and pharynx.*

***Dissection Note:*** For descriptive purposes, the anterior triangle is divided by the digastric and omohyoid muscles into smaller triangles: muscular, carotid, submandibular, and submental. The subdivisions of the anterior triangle will be studied later.

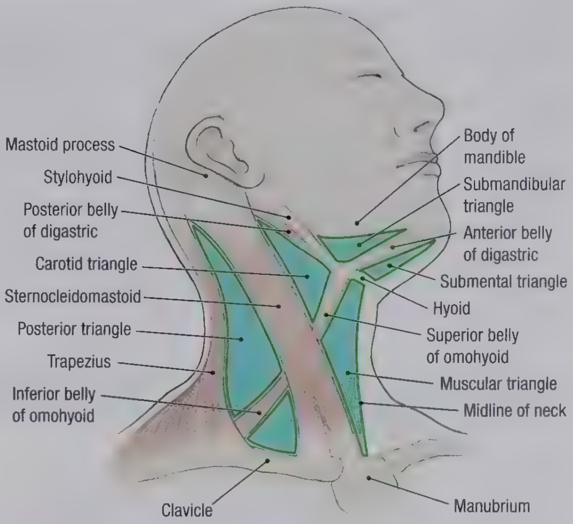

Mastoid process
Stylohyoid
Posterior belly of digastric
Carotid triangle
Sternocleidomastoid
Posterior triangle
Trapezius
Inferior belly of omohyoid
Clavicle
Body of mandible
Submandibular triangle
Anterior belly of digastric
Submental triangle
Hyoid
Superior belly of omohyoid
Muscular triangle
Midline of neck
Manubrium

FIGURE 7.3 ● Boundaries of the cervical triangles. Right anterolateral view.

## Dissection Instructions

### Skin Incisions of the Neck

VIDEO 7.1.1

***Dissection Note:*** Prior to commencing with skin incisions, note that the superficial veins and cutaneous nerves are easily damaged in the neck if skin incisions are made too deeply. It is thus recommended that a partial-thickness skinning technique be implemented in the neck.

1. Refer to FIGURE 7.4.
2. Make an anterior midline skin incision from the chin (C) to the jugular notch of the sternum (E).
3. Make a horizontal skin incision beginning from the midline incision at the chin (C) along body of the mandible that arches superiorly along the jaw line to a point just anterior to the ear lobe (D).
4. Make a skin incision in the transverse plane from the point anterior to the ear lobe (D) to the external occipital protuberance (X). *Note that if the back has been dissected previously, part of this incision has been made.*
5. If the back has not been dissected, make a skin incision along the superior border of the trapezius muscle from the external occipital protuberance (X) to the acromion process of the scapula (I).
6. If the thorax has not been dissected, make an incision from the jugular notch (E) along the anterior surface of the clavicle laterally to the acromion process (I).
7. Beginning at the anterior midline, reflect the skin in the lateral direction as far as the anterior border of the trapezius muscle.
8. Detach the skin of the neck and place it in the tissue container.

***Dissection Note:*** Reflecting the skin with portions still attached will block views of the underlying anatomy, thus it is recommended to completely remove the skin. If the skin is removed in large portions, it may, however, be used later to wrap the neck post dissection to prevent desiccation.

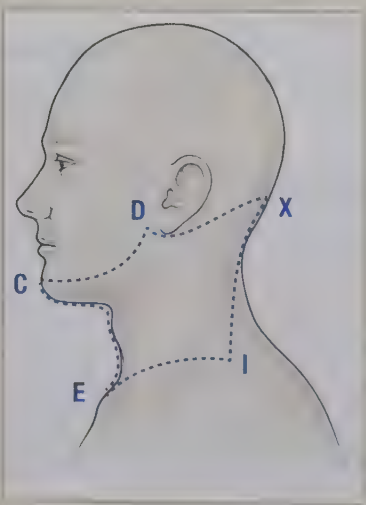


FIGURE 7.4 ● Skin incisions of the neck. Left lateral view.

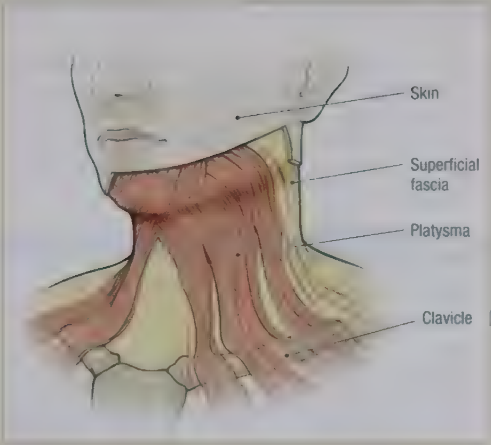

Skin
Superficial fascia
Platysma
Clavicle

FIGURE 7.5 ● The platysma and superficial fascia of the neck. Left anterolateral view.

## Posterior Triangle of the Neck

ATLAS 8.1, 8.3A, 8.8; VIDEO 7.1.2

1. Refer to FIGURE 7.5.
2. Identify the **platysma muscle** in the **superficial fascia** of the neck.
3. Observe that the platysma muscle is very thin and that it covers the bulk of the anterior triangle and the lower part of the posterior triangle of the neck.
4. Observe that the platysma passes superficial to the **clavicle** as it descends toward its inferior attachment in the superficial fascia of the thorax. *Note that some of the structures to be dissected in steps 5 and 6 are in contact with the deep surface of the platysma muscle and care must be taken to preserve them (i.e., supraclavicular nerves, transverse cervical nerve, external jugular vein).*
5. Near the clavicle, raise the inferior border of the platysma muscle near the midline of the neck.
6. Carefully use sharp dissection to free the platysma muscle from the vessels and nerves on its deep surface and reflect the muscle superiorly as far as the mandible leaving it attached along the body of the mandible.
7. Refer to FIGURE 7.6.
8. Identify and clean the **external jugular vein** in the superficial fascia deep to the platysma muscle.
9. Observe that the external jugular vein begins posterior to the angle of the mandible and crosses the superficial surface of the SCM.
10. Follow the external jugular vein inferiorly and observe that about 3 cm superior to the clavicle, it pierces the **investing layer of deep cervical fascia** (roof of the posterior triangle) to drain into the subclavian vein. *Note that the external jugular vein will be followed superiorly during the anterior triangle of the neck dissection.*
11. Along the posterior border of the SCM, identify the **nerve point of the neck**, which contains cutaneous nerve branches of the **cervical plexus**. The cutaneous nerves arising from the nerve point of the neck pass through the posterior triangle of the neck to enter the superficial fascia near the midpoint of the SCM to innervate the skin of the neck and part of the posterior head.
12. Identify the **lesser occipital nerve (C2)**, which parallels the posterior border of the SCM as it passes superiorly. *Note that the lesser occipital nerve supplies the part of the scalp that is immediately posterior to the ear.*
13. Identify and clean the **great auricular nerve (C2, C3)**, which crosses the superficial surface of the SCM parallel to the external jugular vein. *Note that the great auricular nerve supplies the skin of the lower part of the ear, the skin over the parotid gland, and an area of skin extending from the angle of the mandible to the mastoid process.*

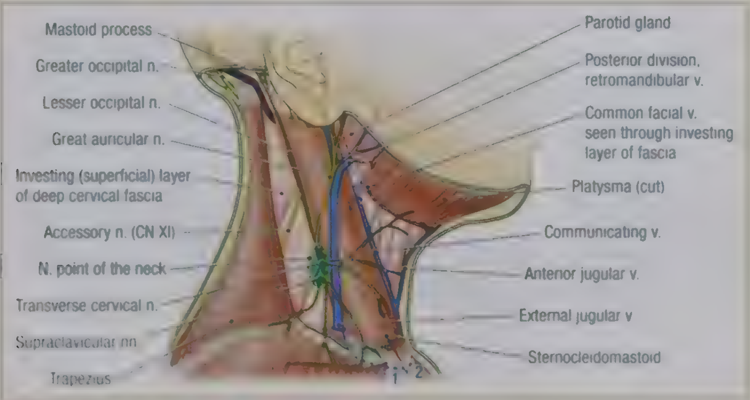

Mastoid process
Greater occipital n.
Lesser occipital n.
Great auricular n.
Investing (superficial) layer of deep cervical fascia
Accessory n. (CN XI)
N. point of the neck
Transverse cervical n.
Supraclavicular nn
Trapezius
1
2
Parotid gland
Posterior division, retromandibular v.
Common facial v. seen through investing layer of fascia
Platysma (cut)
Communicating v.
Anterior jugular v.
External jugular v
Sternocleidomastoid

FIGURE 7.6 ● Boundaries and contents of the posterior triangle of the neck. Right lateral view.

14. Identify and clean the **transverse cervical nerve (C2, C3)**, which passes transversely across the SCM and neck. If you have trouble finding the transverse cervical nerve, it may have been removed with the platysma muscle. *Note that the transverse cervical nerve supplies the skin of the anterior triangle of the neck.*
15. Last, identify and clean the **supraclavicular nerves (C3, C4)**, which pass inferiorly to innervate the skin over the shoulder. Observe medial, intermediate, and lateral branches of the supraclavicular nerves.
16. Identify the **accessory nerve (CN XI)**, which crosses the posterior cervical triangle deep to the investing layer of deep cervical fascia. Observe that the accessory (spinal accessory) nerve courses from slightly superior to the midpoint of the posterior border of the SCM to the superior border of the trapezius muscle.
17. Use blunt dissection to free the accessory nerve from the surrounding connective tissue to verify that it innervates both the SCM and trapezius muscles. *Note that the accessory nerve is a cranial nerve and thus does not originate from the cervical plexus.*
18. Observe that branches of spinal nerves C3 and C4 join the accessory nerve in the posterior cervical triangle to provide proprioceptive sensory innervation to the trapezius. If the back has been dissected, confirm that the accessory nerve may be found on the deep surface of the trapezius muscle.

**CLINICAL CORRELATION**

### Diaphragmatic Referred Pain

ATLAS 3.67, 4.85

Pain and sensory information due to irritation of the mediastinal or diaphragmatic parietal pleura, or the parietal peritoneum lining the inferior aspect of the diaphragm is carried by the phrenic nerves (C3–C5). The internal information of pain is referred to the somatic region of the shoulder via the supraclavicular cutaneous nerves arising from the same vertebral levels.

## Dissection Follow-up

1. Review the boundaries and contents of the posterior triangle of the neck.
2. Review the attachments, actions, and innervations of the muscles of the posterior triangle of the neck in **TABLE 7.1**.
3. Review the fascial distribution of the neck and the structures coursing through the superficial fascial layer.
4. Review the path and distribution of the accessory nerve and its relationship to the fasciae of the neck.
5. Review the area of distribution of the cutaneous branches of the cervical plexus noting their relationship to the SCM and platysma muscles.
6. Replace the reflected tissues of the posterior triangle of the neck in their correct anatomical positions.

**TABLE 7.1 | Muscles of the Posterior Triangle of the Neck**

| *Muscle* | *Superior Attachments* | *Inferior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Trapezius | Superior nuchal line, external occipital protuberance, ligamentum nuchae, SP C7–T12 | Lateral one-third of the clavicle and acromion and spine of scapula | Rotates scapula to tilt the glenoid cavity superiorly, elevates (superior part), retracts (middle part), and depresses (inferior part) scapula | Motor: spinal accessory n. (CN XI)<br>Proprioception: C3–C4 |
| Sternocleidomastoid | Mastoid process, lateral half of superior nuchal line | Anterior surface of manubrium of sternum (sternal head), superior surface of medial one-third of clavicle (clavicular head) | Laterally flexes the head and rotates face to opposite side (unilateral); extends head (bilateral) | Spinal accessory n. (CN XI) |
| Platysma | Mandible, skin of the cheek, angle of the mouth, and orbicularis oris muscle | Superficial fascia of the deltoid and pectoral regions | Tenses the skin of the neck; depresses the mandible | Cervical branch of the facial n. (CN VII) |

Abbreviations: C, cervical vertebrae; CN, cranial nerve; n., nerve; SP, spinous process; T, thoracic vertebrae.

## ANTERIOR TRIANGLE OF THE NECK

### Dissection Overview

The cervical viscera are located within the anterior triangle of the neck and include the thyroid and parathyroid glands, the larynx and trachea (the superior parts of the respiratory tract), and the pharynx and esophagus (the superior parts of the digestive tract). Refer back to FIGURE 7.1 to confirm that the visceral part of the neck is bound posteriorly by the cervical vertebrae, anteriorly by the thin infrahyoid muscles, and bilaterally by the sternocleidomastoid and scalene muscles.

To either side of the cervical viscera and pretracheal fascia are the spaces of the right and left carotid sheaths. The carotid sheath contains the carotid artery (internal carotid artery at more superior levels), the internal jugular vein, and the vagus nerve.

The order of dissection will be as follows: The superficial veins of the anterior triangle will be studied. The contents of each subdivision of the anterior triangle will be dissected in the following order: muscular triangle, submandibular triangle, submental triangle, and carotid triangle.

### Dissection Instructions

#### Superficial Fascia of the Anterior Triangle

ATLAS 8.8A, 8.9; VIDEO 7.2.1

1. Refer back to FIGURE 7.6.
2. Identify the **external jugular vein** lateral to the SCM. *Note that superiorly the external jugular vein is formed by the joining of the posterior division of the retromandibular vein and the posterior auricular vein but do not attempt to identify these vessels at this time.*
3. Identify and clean the superior portion of the **anterior jugular vein** in the superficial fascia near the anterior midline. *Note that inferiorly the anterior jugular vein passes laterally, deep to the SCM, to join the external jugular vein in the root of the neck.*
4. Observe that the anterior jugular vein begins near the hyoid bone and courses inferiorly near the midline of the neck to the suprasternal region where it penetrates the **investing layer of deep cervical fascia**.
5. Look for a **communicating vein** connecting the common facial vein with the anterior jugular vein along the anterior border of the SCM. *Note that the communicating vein, if present, can be very large.*

#### Muscular Triangle

ATLAS 8.9, 8.10, 8.12A; VIDEO 7.2.2

1. Refer to FIGURE 7.7.
2. Palpate the **hyoid bone** at the angle between the floor of the mouth and the superior end of the neck. *Note that the hyoid bone is unique in that it does not articulate with another bone.*

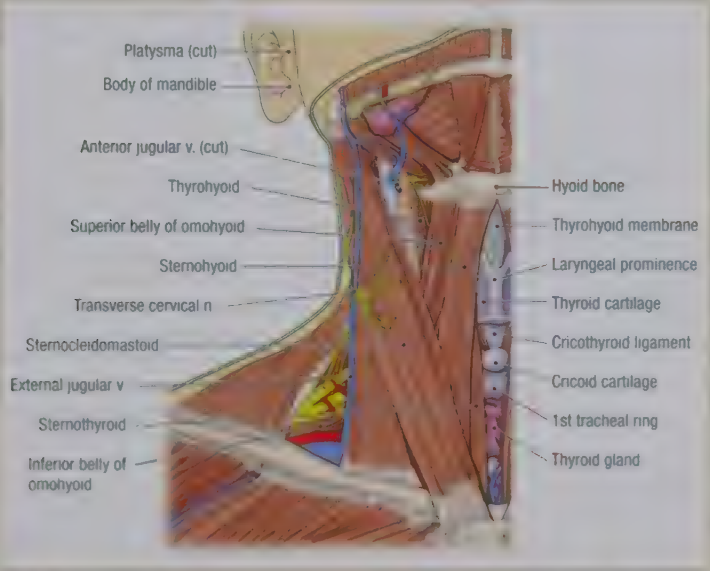

Platysma (cut)
Body of mandible
Anterior jugular v. (cut)
Thyrohyoid
Superior belly of omohyoid
Sternohyoid
Transverse cervical n
Sternocleidomastoid
External jugular v
Sternothyroid
Inferior belly of omohyoid
Hyoid bone
Thyrohyoid membrane
Laryngeal prominence
Thyroid cartilage
Cricothyroid ligament
Cricoid cartilage
1st tracheal ring
Thyroid gland

FIGURE 7.7 ▲ Boundaries and contents of the muscular triangle of the neck. Anterior view.

3. Near the midline of the neck, use blunt dissection to break through the investing layer of the deep cervical fascia and identify the **sternohyoid muscle**.
4. Loosen the medial border of the sternohyoid muscle from the structures that lie deep to it. Make an effort not to disrupt the lateral border of the sternohyoid muscle as the nerves providing motor innervation enter the muscle along the lateral edge.
5. Detach the sternohyoid from its inferior attachment to the sternum and reflect the muscle superiorly. *Note that if the thorax has been dissected previously, the sternohyoid muscle has already been detached from the sternum.*
6. Lateral to the sternohyoid muscle, identify the **superior belly of the omohyoid muscle**.
7. Use blunt dissection to raise the medial border of the superior belly of the omohyoid muscle and loosen it from deeper structures. Make an effort not to disrupt the lateral border of the omohyoid muscle as the nerves providing motor innervation enter the muscle along the lateral edge.
8. Observe that the **muscular triangle** is bounded medially by the **median plane of the neck**, superolaterally by the **superior belly of the omohyoid muscle**, and inferolaterally by the anterior border of the **SCM**.

**CLINICAL CORRELATION**

### Tracheostomy

ATLAS 8.4

Tracheostomy is the placement of a tube through an incisional opening into the airway to ensure airflow in the upper respiratory tract during obstruction or respiratory failure. Surgically, the opening is made in the midline of the neck between the infrahyoid muscles through the tracheal cartilage after careful separation of the isthmus of the thyroid gland.

In life-threatening situations of airway obstruction (e.g., aspiration of a foreign body, edema of the larynx, or paralysis of the vocal folds), an emergency cricothyrotomy (cricothyroidotomy) must be performed. In this procedure, an incision is made superior to the cricoid cartilage (i.e., through the median cricothyroid membrane/ligament). Using this location prevents damage to the vocal cords superiorly and the thyroid gland inferiorly.

9. Deep to the reflected sternohyoid, identify the **sternothyroid** muscle inferiorly and the **thyrohyoid muscle** superiorly.

***Dissection Note:*** The ansa cervicalis innervates three of the four infrahyoid muscles (omohyoid, sternohyoid, and sternothyroid) and will be identified later with the dissection of the carotid sheath. The nerve to the thyrohyoid muscle innervates the thyrohyoid muscle and will similarly be identified at a later stage in the dissection of the neck.

10. Review the attachments and actions of the infrahyoid muscles (see **TABLE 7.2**).
11. Gently retract the right and left sternothyroid muscles to widen the gap in the midline.
12. Inferior to the hyoid, identify the **thyroid cartilage** in the anterior midline of the neck.
13. On the thyroid cartilage, identify the **laryngeal prominence**, or Adam's apple, an extension of cartilage demarking the location of the vocal cords.
14. Identify the **thyrohyoid membrane** stretching between the thyroid cartilage and the hyoid bone.
15. Continue inferiorly from the laryngeal prominence and identify the **cricothyroid ligament (membrane)**. Observe that the cricothyroid ligament attaches along the inferior border of the thyroid cartilage and the superior border of the **cricoid cartilage**.
16. Inferior to the cricoid cartilage, identify the **1st tracheal ring** and observe its proximity to the **isthmus of the thyroid gland**.
17. Observe that the **thyroid gland** is positioned bilaterally on either side of the trachea, deep to the sternothyroid muscle.

## Submandibular Triangle

ATLAS 8.13, 8.14; VIDEO 7.2.3

1. Refer to FIGURE 7.8.
2. On the cadaver, identify the **submandibular gland** and use a probe to gently define its borders. *Note that a portion of the gland extends deep to the posterior border of mylohyoid muscle and will not be visible at this time.*
3. Elevate the platysma and identify the **facial artery** and **facial vein** crossing over the margin of the body of the mandible. Observe that the facial artery is more tortuous than the facial vein and courses more anteriorly.
4. Use blunt dissection to separate the facial artery and vein from the submandibular gland. Observe that the facial vein passes superficial to the submandibular gland and follows a relatively straight path, whereas the facial artery courses deep to the gland and will thus only be visible for a short distance at this time.

***Dissection Note:*** If visibility of the vessels is limited, remove the platysma muscle and the superficial part of the submandibular gland on one side of the face. Do not disturb the deep part of the gland.

5. Identify and clean the superficial surfaces of the **anterior** and **posterior bellies of the digastric muscle**.
6. Observe that the two bellies attach to each other by an intermediate tendon that is attached to the body and the greater horn of the hyoid bone by a **fascial sling**.
7. Identify and clean the **stylohyoid muscle** located anterior to the posterior belly of the digastric muscle. Observe that the **tendon of the stylohyoid muscle** attaches to the body of the hyoid bone by straddling the intermediate tendon of the digastric muscle.

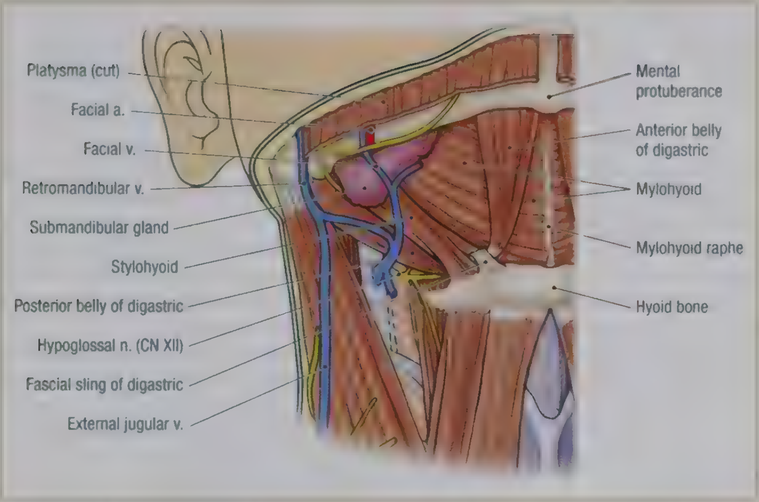


FIGURE 7.8 ■ Boundaries and contents of the submandibular and submental triangles of the neck. Anterior view.

8. On the lateral aspect of the neck, identify the **hypoglossal nerve (CN XII)** coursing lateral to the carotid arteries.
9. Observe that the hypoglossal nerve enters the submandibular triangle by passing deep to the posterior belly of the digastric muscle and then passes deep to the **mylohyoid muscle** within the submandibular triangle to enter the floor of the mouth.
10. Use blunt dissection to follow the hypoglossal nerve through the submandibular triangle for a short distance toward the tongue.
11. Observe that the **submandibular triangle** is bounded superiorly by the **inferior border (body) of the mandible**, anteroinferiorly by the **anterior belly of the digastric muscle**, and posteroinferiorly by the **posterior belly of the digastric muscle**. *Note that the submandibular triangle has a superficial boundary (roof) formed by the investing layer of the deep cervical fascia and a deep boundary (floor) formed by the mylohyoid and hyoglossus muscles.*

## Submental Triangle

ATLAS 8.9, 8.11A, 8.12A; VIDEO 7.2.4

1. Refer to FIGURE 7.8.
2. Identify the **mylohyoid muscle** in the midline of the neck deep to the anterior bellies of the right and left digastric muscles. Observe that the right and left mylohyoid muscles fuse in the midline at the **mylohyoid raphe**.
3. Clean the superficial fascia from the surface of the right and left mylohyoid muscles removing and remnants of superficial fascia or lymphatics in the region.
4. Observe that the **submental triangle** is bounded **inferiorly** by the hyoid bone and on the **right and left** by the anterior bellies of the right and left digastric muscles. *Note that the submandibular triangle has a superficial boundary (roof) formed by the investing layer of the deep cervical fascia and a deep boundary (floor) formed by the mylohyoid muscle.*

## Carotid Triangle

ATLAS 8.14, 8.15C, 8.16; VIDEO 7.2.5

1. Refer back to FIGURE 7.6.
2. Clean the anterior border of the SCM from its inferior attachments to the **clavicle** and **sternum** to its superior attachment on the **mastoid process**. *Note that if the thorax has been dissected previously, the inferior attachment of the SCM has either already been detached or will have remained attached depending on the approach used.*
3. Observe that at its superior end, the SCM is in contact with the parotid gland. Separate the SCM superiorly from the **parotid gland** using sharp dissection leaving the superior attachment of the SCM intact.
4. If the thorax has not been dissected, detach the SCM from the medial third of the clavicle (**Cut 1**) and the manubrium of the sternum (**Cut 2**), cutting as close to the bone as possible.
5. Use blunt dissection to separate the SCM from the investing fascia that lies posterior to it and reflect it superiorly. While reflecting the SCM, attempt to conserve the cutaneous branches of the cervical plexus that radiate from the posterior border of the SCM and leave them attached to the cervical vertebral column.

6. Use blunt dissection to free the SCM from the investing fascia as far superiorly as the mastoid process. Doing so will facilitate the future dissection of the parotid region.
7. Refer to FIGURE 7.9.
8. Find the **accessory nerve (CN XI)** where it crosses the deep surface of the SCM near the base of the skull and trace it superiorly as far as possible. *Note that the accessory nerve passes through the jugular foramen to exit the skull, but this relationship is too far superior to be seen at this time.*
9. Place the SCM back in anatomical position and observe that the **carotid triangle** is bounded superiorly by the **posterior belly of the digastric muscle**, inferomedially by the **superior belly of the omohyoid muscle**, and inferolaterally by the anterior border of the **SCM**.
10. Use blunt dissection to clean the **inferior belly of the omohyoid muscle**.
11. Observe that the inferior belly and superior belly of the omohyoid are joined by an **intermediate tendon** bound to the clavicle by a fascial sling.
12. Review the attachments and actions of the omohyoid muscle (see **TABLE 7.2**).
13. Palpate the **tip of the greater horn of the hyoid bone** and observe its close proximity of the **hypoglossal nerve (CN XII)**.
14. Identify the **nerve to thyrohyoid**, which appears to branch from the hypoglossal nerve. *Note that the nerve to thyrohyoid originates from spinal nerve C1, though it travels with the hypoglossal nerve to reach the thyrohyoid muscle.*
15. Clean a portion of the carotid sheath and identify the **superior root of the ansa cervicalis**, which travels with the hypoglossal nerve. *Note that the superior root of the ansa cervicalis is mainly composed of fibers from the anterior ramus of the C1 spinal nerve.*
16. Identify the **inferior root of the ansa cervicalis** (anterior rami of C2, C3), which passes around the lateral side of the carotid sheath to join the superior root forming a "loop."
17. Clean the ansa cervicalis and trace its delicate branches to the lateral borders of the infrahyoid muscles.
18. Use blunt dissection to raise the posterior border of the thyrohyoid muscle and identify the **thyrohyoid membrane** extending between the thyroid cartilage and the hyoid bone.
19. Identify the **internal branch of the superior laryngeal nerve** where it passes through the thyrohyoid membrane. *Note that the internal branch of the superior laryngeal nerve supplies sensory fibers to the mucosa of the larynx above the level of the vocal cords.*
20. Follow the internal branch of the superior laryngeal nerve superiorly to the point where the superior laryngeal nerve divided into **internal** and **external branches**. *Note that the superior laryngeal nerve may be too far superior to be seen at this stage of the dissection, if this is the case, continue to look for it as you work superiorly in later dissections.*
21. Refer to FIGURE 7.10.
22. Trace the external branch of the superior laryngeal nerve inferiorly to the **cricothyroid muscle**, which it innervates. *Note that the external branch of the superior laryngeal nerve also innervates part of the inferior pharyngeal constrictor muscle.*
23. While preserving the ansa cervicalis, use scissors to open the **carotid sheath** by making a vertical incision through the fascia of the sheath paralleling the underlying large vessels.

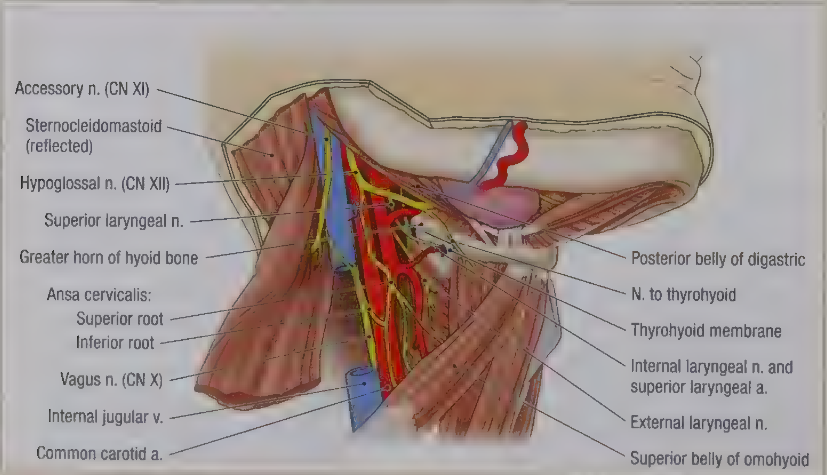

Accessory n. (CN XI)
Sternocleidomastoid (reflected)
Hypoglossal n. (CN XII)
Superior laryngeal n.
Greater horn of hyoid bone
Ansa cervicalis:
Superior root
Inferior root
Vagus n. (CN X)
Internal jugular v.
Common carotid a.
Posterior belly of digastric
N. to thyrohyoid
Thyrohyoid membrane
Internal laryngeal n. and superior laryngeal a.
External laryngeal n.
Superior belly of omohyoid

FIGURE 7.9 ■ Boundaries and contents of the carotid triangle of the neck. Right lateral view.

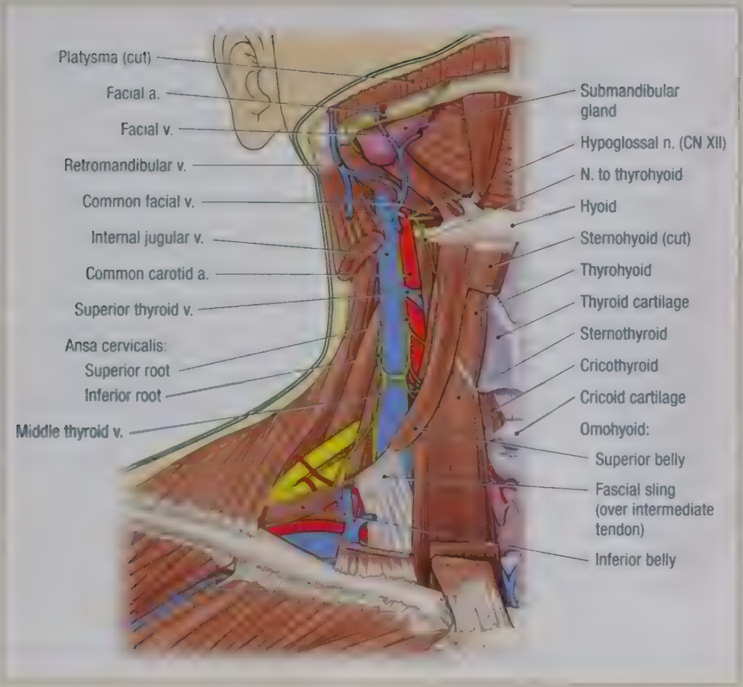

Platysma (cut)
Facial a.
Facial v.
Retromandibular v.
Common facial v.
Internal jugular v.
Common carotid a.
Superior thyroid v.
Ansa cervicalis:
Superior root
Inferior root
Middle thyroid v.
Submandibular gland
Hypoglossal n. (CN XII)
N. to thyrohyoid
Hyoid
Sternohyoid (cut)
Thyrohyoid
Thyroid cartilage
Sternothyroid
Cricothyroid
Cricoid cartilage
Omohyoid:
Superior belly
Fascial sling (over intermediate tendon)
Inferior belly

FIGURE 7.10 ■ Contents of the carotid sheath. Anterior view.

24. Within the carotid sheath, identify the **internal jugular vein**, the **common carotid artery**, and the **vagus nerve (CN X)**. Observe that the internal jugular vein is located lateral to the common carotid artery in the carotid sheath, whereas the vagus nerve lies between and deep to both vessels.
25. Follow the common carotid artery superiorly and identify its point of bifurcation into the **internal** and **external carotid arteries**. Observe that the external carotid artery is located anterior to the internal carotid artery.
26. Use blunt dissection to separate the internal jugular vein from the common and internal carotid arteries.
27. Identify the largest tributaries of the internal jugular vein, the **common facial vein, superior thyroid vein**, and **middle thyroid vein**. To clear the dissection field, you may remove the three tributaries of the internal jugular vein.
28. Refer to FIGURE 7.11.
29. Identify and clean the **vagus nerve (CN X)** within the carotid sheath where it lies between and posterior to the common carotid artery and internal jugular vein. To see the vagus nerve, retract the internal jugular vein laterally and the common carotid artery medially.
30. Follow the vagus nerve superiorly to identify the point of origin of the superior laryngeal nerve near the **inferior vagal (nodose) ganglion**, a dilation of the vagus nerve near the height of the 1st cervical vertebra. *Note that the nodose ganglion is often difficult to find but is near the point of origin for the laryngeal, pharyngeal, and palatal branches of the vagus nerve and contains the sensory cell bodies for the vagus nerve to targets including the heart, lungs, and gastrointestinal tract.*

## External Carotid Artery

ATLAS 8.14, 8.15C; VIDEO 7.2.6

1. Refer to FIGURE 7.11.
2. Identify the origin of the external carotid artery near the level of the superior border of the thyroid cartilage and use blunt dissection to follow it superiorly until it passes on the medial side of (deep to) the posterior belly of the digastric muscle.
3. The external carotid artery has six branches in the carotid triangle, although only five of them will be dissected at this time. *Note that each branch of the external carotid artery has a companion vein, which may be removed to clear the dissection field.*
4. Beginning inferiorly, identify and clean the **superior thyroid artery** arising from the anterior surface of the external carotid artery near the level of the superior horn of the thyroid cartilage. Follow the superior

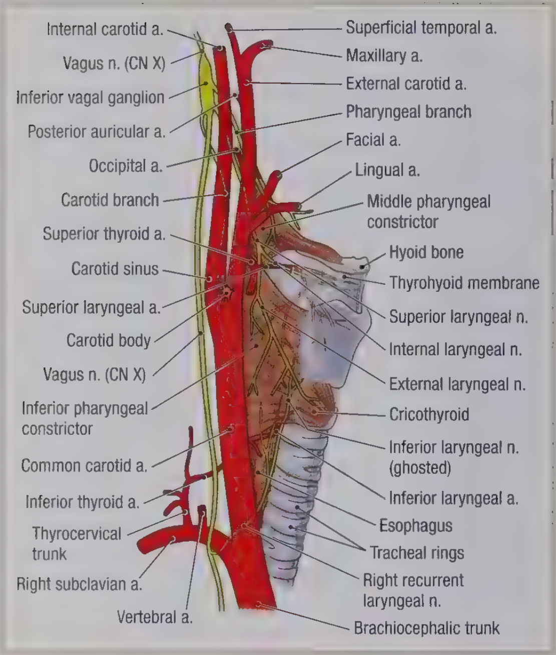

Internal carotid a.
Vagus n. (CN X)
Inferior vagal ganglion
Posterior auricular a.
Occipital a.
Carotid branch
Superior thyroid a.
Carotid sinus
Superior laryngeal a.
Carotid body
Vagus n. (CN X)
Inferior pharyngeal constrictor
Common carotid a.
Inferior thyroid a.
Thyrocervical trunk
Right subclavian a.
Vertebral a.
Superficial temporal a.
Maxillary a.
External carotid a.
Pharyngeal branch
Facial a.
Lingual a.
Middle pharyngeal constrictor
Hyoid bone
Thyrohyoid membrane
Superior laryngeal n.
Internal laryngeal n.
External laryngeal n.
Cricothyroid
Inferior laryngeal n. (ghosted)
Inferior laryngeal a.
Esophagus
Tracheal rings
Right recurrent laryngeal n.
Brachiocephalic trunk

FIGURE 7.11 ● Branches of the external carotid artery and right vagus nerve (CN X) in the neck. Right lateral view.

thyroid artery inferiorly toward the superior pole of the lobe of the thyroid gland.

5. Identify the **superior laryngeal artery**, a branch of the superior thyroid artery, which pierces the thyrohyoid membrane together with the internal branch of the superior laryngeal nerve.
6. Superior to the origin of the superior thyroid artery, identify the **lingual artery** arising off the anterior surface of the external carotid artery.
7. Clean the lingual artery for a short distance and observe it arises near the level of the greater horn of the hyoid bone and courses in parallel to the **hypoglossal nerve (CN XII)**. *Note that the lingual artery passes deeply into the muscles of the tongue and will be isolated during a future dissection.*
8. Identify the **facial artery** arising from the anterior surface of the external carotid artery immediately superior to the lingual artery.
9. Follow the facial artery along its path and observe that it passes medial to the posterior belly of the digastric muscle and deep to the superficial part of the submandibular gland. Recall that the facial artery crosses the inferior border of the mandible to enter the face anterior to the corresponding facial vein. Do not follow it into the face at this time. *Note that in some individuals, the lingual and facial arteries arise from a common trunk.*
10. On the posterior surface of the external carotid artery, identify the **occipital artery**, which supplies blood to part of the scalp. If the suboccipital region was previously dissected, the distal portion of this vessel was previously identified.
11. Superior to the origin of the occipital artery, identify the **posterior auricular artery**. The posterior auricular artery arises from the posterior surface of the external carotid artery and passes posterior to the ear to supply part of the scalp. *Note that this branch may not be visible if the SCM was not reflected completely in the earlier part of the dissection.*
12. Use blunt dissection to clean the bifurcation of the common carotid artery and identify the **carotid sinus**, a dilation of the internal carotid artery near its origin. *Note that the wall of the carotid sinus contains baroreceptor that monitors blood pressure and that it is innervated by the glossopharyngeal nerve (CN IX) and the vagus nerve (CN X).*
13. On the medial aspect of the carotid bifurcation, make an effort to identify the **carotid body**, a small mass of nerve tissue that contains chemoreceptors to monitor changes in oxygen and carbon dioxide concentration of the blood. *Note that the carotid body is innervated by the glossopharyngeal nerve (CN IX) and the vagus nerve (CN X).*
14. Identify the **ascending pharyngeal artery**, the sixth branch of the external carotid artery, which arises from its medial surface close to the bifurcation of the common carotid artery. *Note that the ascending pharyngeal artery is quite small and is often difficult to see from this orientation.*

## Dissection Follow-up

1. Review the boundaries and contents of the anterior triangle of the neck as well as the subdivisions of the carotid, muscular, submental, and submandibular triangles.
2. Review the attachments, actions, and innervations of the muscles of the anterior triangle of the neck in **TABLE 7.2**.
3. Review the contents and respective locations of the contents of the carotid sheath.
4. Review the branches of the external carotid artery noting their relationships to muscles, nerves, and glands in the region.
5. Review the branches of the superior laryngeal nerve and note their distribution.
6. Review the course of the hypoglossal nerve and its relation to the vessels in the neck.
7. Review the structures forming the ansa cervicalis and its relationship to the hypoglossal nerve and carotid sheath.
8. Replace the reflected tissues of the anterior triangle of the neck in their correct anatomical positions.

**TABLE 7.2** **Muscles of the Anterior Triangle of the Neck**

INFRAHYOID MUSCLES

| *Muscle* | *Superior Attachments* | *Inferior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Sternohyoid | Body of hyoid bone | Posterior surface of manubrium of sternum | Depresses the hyoid | Ansa cervicalis (C1–C3) |
| Omohyoid | Inferior border of hyoid bone | Superior border of scapula near suprascapular notch | Depresses and retracts the hyoid | |
| Sternothyroid | Oblique line of the thyroid cartilage | Posterior surface of manubrium of sternum | Depresses thyroid cartilage and larynx | |
| Thyrohyoid | Inferior border of body and greater horn of hyoid | Oblique line of thyroid cartilage | Depresses hyoid and elevates the thyroid cartilage and larynx | C1 via hypoglossal n. (CN XII) |

SUPRAHYOID MUSCLES

| *Muscle* | *Superior Attachments* | *Inferior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Digastric | Mastoid process and digastric groove of the temporal bone (posterior belly) | Digastric fossa of mandible (anterior belly) | Elevates hyoid and depresses mandible | Nerve to mylohyoid (CN $V_3$) (anterior belly), facial n. (CN VII) (posterior belly) |
| Stylohyoid | Styloid process | Body of the hyoid | Elevates hyoid | Facial n. (CN VII) |
| Mylohyoid | Mylohyoid line of mandible (lateral attachment) | Hyoid bone and the mylohyoid raphe (medial attachment) | Supports the floor of the oral cavity | Nerve to mylohyoid (CN $V_3$) |

Abbreviations: C, cervical vertebrae; CN, cranial nerve; n., nerve.

# THYROID AND PARATHYROID GLANDS

## Dissection Overview

The glands are located in the visceral compartment of the neck and lie deep to the infrahyoid muscles and superficial to the larynx and trachea. As endocrine organs, the thyroid and parathyroid glands secrete their hormones without ducts directly into the cardiovascular system and thus have a rich arterial supply and venous drainage. The thyroid gland is regulated by the pituitary gland and produces thyroxine ($T_3$) and triiodothyronine ($T_4$) to control the rate of metabolic function and calcitonin to regulate calcium metabolism. The parathyroid glands produce parathyroid hormone (PTH), which assists in the metabolism of calcium and phosphorous.

The order of dissection will be as follows: The thyroid gland and associated vasculature will be identified. The recurrent laryngeal nerve will be identified and studied. The parathyroid glands will be identified.

## Dissection Instructions

### Thyroid and Parathyroid Glands

ATLAS 8.18, 8.19, 8.21; VIDEO 7.3.1

1. Refer to FIGURE 7.12.
2. Reflect the sternocleidomastoid, sternohyoid, and sternothyroid muscles superiorly.
3. Identify the **right** and **left lobes** of the **thyroid gland** located at vertebral levels C5–T1.
4. Observe that the two lobes are connected by the **isthmus**, which crosses the anterior surface of tracheal rings 2 and 3.
5. Identify the **pyramidal lobe**, if present, that extends superiorly from the isthmus. *Note that the pyramidal lobe is a remnant of embryonic development that shows the route of descent of the thyroid gland.*
6. Observe that laterally, the thyroid gland is in contact with the carotid sheath and thus in close proximity to the common carotid artery and internal jugular vein.
7. Identify and clean the **superior thyroid artery**, a branch of the external carotid artery, where it enters the superior end of the thyroid gland lobe. *Note that the inferior thyroid artery will be dissected later.*
8. Identify and clean the **superior and middle thyroid veins**, which are tributaries of the internal jugular vein.

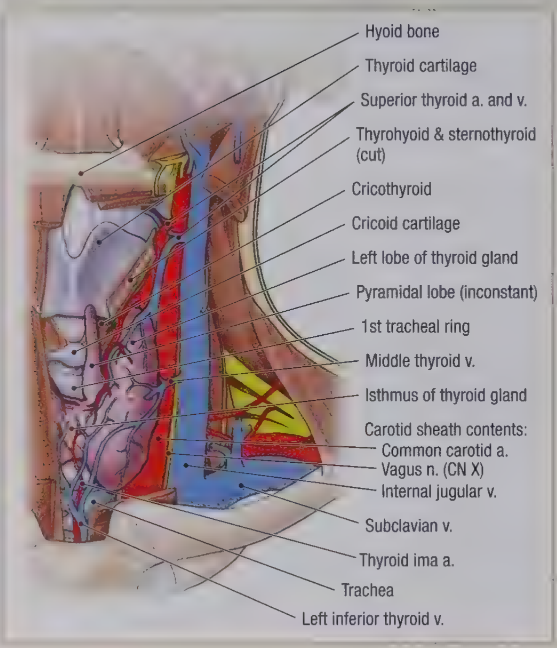

Hyoid bone
Thyroid cartilage
Superior thyroid a. and v.
Thyrohyoid & sternothyroid (cut)
Cricothyroid
Cricoid cartilage
Left lobe of thyroid gland
Pyramidal lobe (inconstant)
1st tracheal ring
Middle thyroid v.
Isthmus of thyroid gland
Carotid sheath contents:
Common carotid a.
Vagus n. (CN X)
Internal jugular v.
Subclavian v.
Thyroid ima a.
Trachea
Left inferior thyroid v.

FIGURE 7.12 ● Arterial supply and venous drainage of the thyroid gland. Anterior view.

### CLINICAL CORRELATION

#### Recurrent Laryngeal Nerve Injury

ATLAS 3.60B, 8.20

The recurrent laryngeal nerve may be injured during thyroidectomy (removal of the thyroid gland) or compressed by a thyroid tumor, causing full or partial paralysis of the laryngeal muscles on the affected side resulting in hoarseness of the voice.

9. Identify the **inferior thyroid veins**, which descend into the thorax on the anterior surface of the trachea to drain into the right and left brachiocephalic veins.
10. Look for the **thyroid ima artery**, which when present enters the thyroid gland inferiorly near the midline.
11. Follow the thyroid ima artery inferiorly toward its point of origin from either the arch of the aorta, the right common carotid artery, or the right subclavian artery. *Note that the thyroid ima artery is a relatively rare but clinically significant variant as punctures through the trachea may pierce this vessel.*
12. Use scissors to cut the isthmus of the thyroid gland.
13. Use blunt dissection to detach the isthmus from the tracheal rings and spread the lobes widely apart.
14. On both sides of the cadaver, use blunt dissection to display the **recurrent laryngeal nerves** that pass immediately posterior to the lobes of the thyroid gland in the groove between the trachea and esophagus.
15. Cut all blood vessels leading to or from the left lobe of the thyroid gland and, using blunt dissection, free the left lobe from the surrounding connective tissue to remove it from the dissection field.
16. Examine the posterior aspect of the left lobe of the thyroid gland and attempt to identify the **parathyroid glands**. The parathyroid glands are about 5 mm in diameter and may be darker in color and harder in texture than the thyroid gland. Usually, there are two parathyroid glands on each side of the thyroid gland but the number can vary from one to three.

### CLINICAL CORRELATION

#### Thyroidectomy

ATLAS 8.21

The thyroid gland plays a key role in metabolic function for the body. A thyroidectomy is the surgical removal of the thyroid gland, which is most commonly performed for malignancy (cancer). During a thyroidectomy, the small parathyroid glands located on the thyroid's posterior surface are in danger of being damaged or removed. As the parathyroid glands play an important role in the regulation of calcium metabolism, to maintain proper serum calcium levels without medication, at least one parathyroid gland must be retained during surgical removal of the thyroid.

## Dissection Follow-up

1. Review the relationship of the thyroid gland to the infrahyoid muscles, carotid sheaths, larynx, and trachea.
2. Review the blood supply and venous drainage of the thyroid gland noting the variation between the arteries and veins.
3. Review the relationship of the parathyroid glands to the thyroid gland.
4. Use an embryology textbook to review the origin and migration of the thyroid and parathyroid glands during development.
5. Place the removed left thyroid lobe in a tissue container and replace any reflected tissues of the neck in their correct anatomical positions.

# ROOT OF THE NECK

## Dissection Overview

The root (base) of the neck is the junction between the thorax and the neck. The root of the neck is an important area because it lies superior to the superior thoracic aperture and all structures that pass between the head and thorax, or the upper limb and thorax, must pass through the root of the neck.

The order of dissection will be as follows: The veins of the root of the neck will be identified and studied. The lymphatic drainage into the venous angles will be studied. The vagus and phrenic nerves and the sympathetic trunk will be studied. The muscles that form the floor of the posterior cervical triangle will be studied. The subdivisions and branches of the subclavian artery will be dissected.

## Dissection Instructions

### Root of the Neck

ATLAS 8.22, 8.23, 8.24A; VIDEO 7.4.1

***Dissection Note:*** If the clavicle was cut at its mid length and the thoracic wall removed during dissection of the thorax, remove the anterior thoracic wall and set it aside.

1. Refer to FIGURE 7.13.
2. Reflect the sternocleidomastoid, sternohyoid, and sternothyroid muscles superiorly.
3. Use scissors to cut the fascial sling that binds the intermediate tendon of the omohyoid muscle to the clavicle.
4. Follow the **external jugular vein** inferiorly from the upper part of the neck until it passes through the investing layer of deep cervical fascia near the clavicle. *Note that the external jugular vein is the only tributary of the subclavian vein.*
5. To expose the blood vessels in the root of the neck, remove the investing layer of deep cervical fascia that forms the roof of the lower part of the posterior cervical triangle making an effort to preserve the external jugular vein.
6. Identify the **subclavian vein** and use blunt dissection to loosen it from the surrounding deep structures.
7. Follow the subclavian vein medially to the point where it is joined by the **internal jugular vein** to form the **brachiocephalic vein**. *Note that the vertebral vein joins the posterior surface of the brachiocephalic vein in the root of the neck but it cannot be seen at this time.*

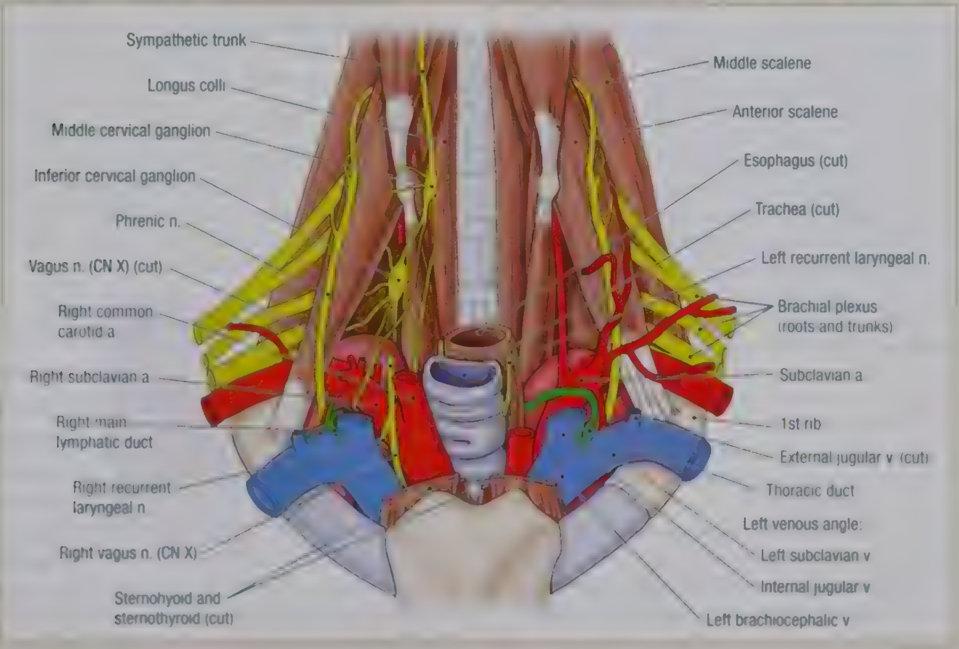

Sympathetic trunk
Longus colli
Middle cervical ganglion
Inferior cervical ganglion
Phrenic n.
Vagus n. (CN X) (cut)
Right common carotid a
Right subclavian a
Right main lymphatic duct
Right recurrent laryngeal n
Right vagus n. (CN X)
Sternohyoid and sternothyroid (cut)
Middle scalene
Anterior scalene
Esophagus (cut)
Trachea (cut)
Left recurrent laryngeal n.
Brachial plexus (roots and trunks)
Subclavian a
1st rib
External jugular v (cut)
Thoracic duct
Left venous angle:
Left subclavian v
Internal jugular v
Left brachiocephalic v

FIGURE 7.13 ● Root of the neck with clavicles removed. Anterior view.

8. Identify the **subclavian artery** and observe that the right subclavian artery is a branch of the brachiocephalic trunk and that the left subclavian artery is a branch of the aortic arch.
9. On the left side, find the **thoracic duct**, which ascends from the thorax into the neck.
10. Observe that the thoracic duct is posterior to the esophagus at the level of the superior thoracic aperture and then arches anteriorly and to the left to join the venous system near the **left venous angle** at the junction of the **left subclavian vein** and the **left internal jugular vein**. *Note that the thoracic duct is usually a single structure, which has the diameter of a small vein, but it may be represented by several smaller ducts.*
11. On the right side of the neck, observe that several small lymphatic vessels join with lymph vessels from the right upper limb and right side of the thorax to form the **right lymphatic duct**.
12. Observe that the right lymphatic duct drains into the **right venous angle**, the junction of the right subclavian vein and right internal jugular vein.
13. On both sides of the neck, find the **vagus nerve (CN X)** in the carotid sheath and follow it into the thorax. Recall that the vagus nerve passes posterior to the root of the lung while it descends through the thorax.
14. As the right vagus nerve passes anterior to the subclavian artery, it gives off the **right recurrent laryngeal nerve**. Similarly, as the left vagus nerve descends on the left side of the thorax anterior to the aortic arch, it gives off the **left recurrent laryngeal nerve**.
15. Follow the right and left recurrent laryngeal nerves superiorly along the lateral surface of the trachea and esophagus as far as the 1st tracheal ring. Do not follow them into the larynx at this time.
16. Verify that the **phrenic nerve** crosses the anterior surface of the anterior scalene muscle. Recall that the phrenic nerve arises from vertebral levels C3–C5 and provides motor innervation to the diaphragm and sensory innervation to the mediastinal and diaphragmatic parietal pleura.
17. Follow the phrenic nerve into the thorax and confirm that it passes anterior to the root of the lung along its path to the diaphragm.
18. Identify the cervical portion of the **sympathetic trunk** and verify that it is continuous with the thoracic sympathetic trunk.
19. Identify the **inferior cervical ganglion** low in the neck near the superior thoracic aperture. *Note that the inferior cervical ganglion often fuses with the 1st thoracic ganglion to form the cervicothoracic (stellate) ganglion.*
20. Identify the **middle cervical ganglion** midway up the cervical sympathetic chain and the **superior cervical ganglion** high in the neck near the level of the mastoid process.
21. Examine the muscles that form the floor of the posterior cervical triangle and identify the splenius capitis; the levator scapulae; and the **anterior**, **middle**, and **posterior scalene muscles**.
22. Use blunt dissection to define the borders of the anterior scalene and middle scalene muscles and follow them inferiorly to observe that they both attach to the 1st rib. The 1st rib and the adjacent borders of the anterior and middle scalene muscles form the boundaries of the **interscalene triangle**.
23. Review the attachments, actions, and innervations of the scalene muscles (see **TABLE 7.3**).
24. Observe that the **subclavian artery** and the **roots of the brachial plexus** pass between the middle scalene muscle and the anterior scalene muscle (through the interscalene triangle).
25. Crossing over the anterior surface of the anterior scalene muscle, identify the **subclavian vein**, **transverse cervical artery**, and **suprascapular artery**.
26. Use blunt dissection to clean the **roots of the brachial plexus** at the level of the interscalene triangle. Identify the parts of the **supraclavicular portion of the brachial plexus: five roots, three trunks**, and **six divisions**.
27. If the upper limb has been dissected previously, follow the suprascapular nerve as far laterally as the suprascapular notch where it is joined by the suprascapular artery.

## Subclavian Artery

ATLAS 8.15, 8.23; VIDEO 7.4.2

1. Refer to FIGURE 7.14.
2. The subclavian artery has three parts that are defined by its relationship to the anterior scalene muscle.

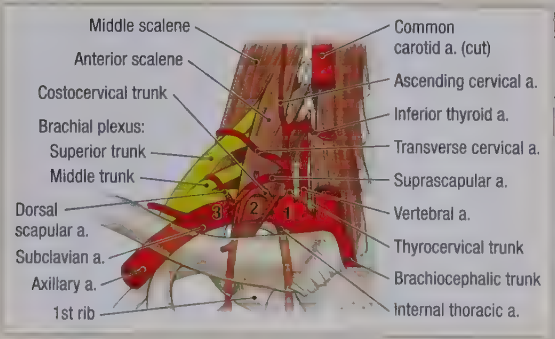


FIGURE 7.14 ● Branches of the subclavian artery. Anterior view.

Identify the first part of the subclavian artery, from its origin to the medial border of the anterior scalene muscle. The first part of the subclavian artery has three branches: the vertebral artery, internal thoracic artery, and thyrocervical trunk.

3. Identify the **vertebral artery,** which courses superiorly between the anterior scalene muscle and the longus colli muscle. Trace the vertebral artery superiorly until it passes into the transverse foramen of vertebra C6.
4. Identify the **internal thoracic artery,** which arises from the anteroinferior surface of the subclavian artery and passes inferiorly to supply the anterior thoracic wall. *Note that the internal thoracic artery was cut with the removal of the anterior thoracic wall.*
5. Identify the **thyrocervical trunk,** which arises from the anterosuperior surface of the subclavian artery. The thyrocervical trunk typically has three branches named according to their respective paths or targets.
6. Branching off the thyrocervical trunk, identify the **transverse cervical artery**. The transverse cervical artery crosses the root of the neck 2 to 3 cm superior to the clavicle and deep to the omohyoid muscle and supplies the trapezius.
7. Branching off the thyrocervical trunk, identify the **suprascapular artery,** which passes laterally and posteriorly to the region of the suprascapular notch. In the shoulder, the suprascapular artery passes superior to the transverse scapular ligament and supplies the supraspinatus and infraspinatus muscles.
8. Identify the last branch off the thyrocervical trunk, the **inferior thyroid artery,** which courses medially toward the thyroid gland. *Note that the inferior thyroid artery usually passes posterior to the cervical sympathetic trunk.*
9. Branching off the inferior thyroid artery, ascending in the neck, identify the **ascending cervical artery**.
10. Return to the subclavian artery and identify the second part, which lies posterior to the anterior scalene muscle. The second part of the subclavian artery has one branch, the **costocervical trunk,** which arises from its posterior surface.
11. Use blunt dissection to elevate the subclavian artery from the surface of the 1st rib and use blunt dissection to look for the costocervical trunk passing posteriorly above the cupula of the pleura. The costocervical trunk divides into the **deep cervical artery** and the **supreme intercostal artery**. The supreme intercostal artery gives rise to posterior intercostal arteries 1 and 2.
12. Return to the subclavian artery and identify the third part between the lateral border of the anterior scalene muscle and the lateral border of the 1st rib.
13. The third part of the subclavian artery has one branch, the **dorsal scapular artery**. The dorsal scapular artery passes between the superior and middle trunks of the brachial plexus to supply the muscles of the scapular region. *Note that in some individuals, the dorsal scapular artery arises from the transverse cervical artery instead of from the subclavian artery.*

**CLINICAL CORRELATION**

### Thoracic Outlet Syndrome

ATLAS 3.10B, 8.8G

Thoracic outlet syndrome is a collective term for compression of the neurovascular structures passing to the upper limb via the thoracic outlet at the root of the neck. Symptoms of thoracic outlet syndrome include pain, numbness, discoloration, tingling, or weakness of the upper limb associated with the ischemia or nerve dysfunction. Because the interscalene triangle is the point of emergence for the brachial plexus, and the pathway of the subclavian artery, it is a common site of compression and of particular clinical concern. Additional muscular slips, shortening and widening of the scalene muscles, or an accessory cervical rib may all narrow the interval within the interscalene triangle.

## Dissection Follow-up

1. Review the boundaries and contents of the interscalene triangle.
2. Review the attachments, actions, and innervation of the scalene muscles in **TABLE 7.3**.
3. Review the paths of the vagus, recurrent laryngeal, and phrenic nerves.
4. Review the pattern of lymphatic drainage into the venous system at the root of the neck.
5. Review the course of sympathetic fibers to the head and neck.
6. Review the branches arising from the arch of the aorta within the thorax to supply the upper limbs and head and neck.
7. Review the three parts and branches of the subclavian artery.
8. Replace the anterior thoracic wall and any reflected tissue back in its correct anatomical position.

TABLE [illegible] Scalene Muscles

| Muscle | Superior Attachments | Inferior Attachments | Actions | Innervation |
|---|---|---|---|---|
| Anterior scalene | TP of C4–C6 | 1st rib | Flexes neck, elevates 1st rib during inspiration | Anterior rami C4–C6 |
| Middle scalene | Posterior tubercles of TP of C2–C7 | | | Anterior rami C2–C6 |
| Posterior scalene | Posterior tubercles of TP of C4–C6 | 2nd rib | Flexes neck laterally, elevates 2nd rib during inspiration | Anterior rami C7–C8 |

Abbreviations: C, cervical vertebrae; TP, transverse process.

# FACE

## Dissection Overview

Sensory innervation for the skin of the face is provided by three divisions (branches) of the trigeminal nerve (CN V) as shown in FIGURE 7.15. The ophthalmic division (CN $V_1$) innervates the skin of the forehead, upper eyelids, and nose. The maxillary division (CN $V_2$) innervates the skin of the lower eyelid, cheek, and upper lip. The mandibular division (CN $V_3$) innervates the skin of the lower face and part of the side of the head. Branches of the second and third cervical spinal nerves (C2–C3) innervate the skin of the neck and posterior part of the head.

The superficial fascia of the face contains the parotid gland, muscles of facial expression, branches of the facial nerve (CN VII), branches of the trigeminal nerve (CN V), and branches of the facial artery and vein. The motor innervation to all muscles of facial expression is provided by the facial nerve (CN VII).

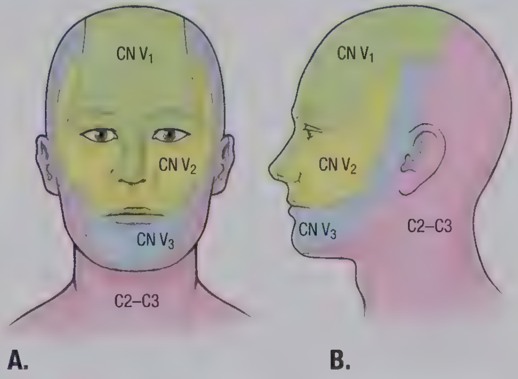


FIGURE 7.15 ● Dermatome map of the face and neck. **A.** Anterior view. **B.** Left lateral view.

The order of dissection will be as follows: The skin of the face will be removed to expose the superficial fascia. The parotid duct and gland will be identified. Branches of the facial nerve will be identified as they emerge from the anterior border of the parotid gland. The muscles of facial expression will be studied. The terminal branches of the three divisions of the trigeminal nerve will be exposed where they emerge from openings in the skull.

### Skeletal Anatomy

Refer to an articulated skeleton or disarticulated lower limb skeleton to identify the following skeletal features.

### *Anterior View of the Skull*

ATLAS 7.2

***Dissection Note:*** All parts of the skull are fragile, but the bones of the orbit and nasal cavity are exceptionally delicate. Because the medial wall of the orbit is very easily broken, **never hold a skull by placing your fingers into the orbits**. Similarly, the small bony projections (processes) extending from the inferior surface of the skull can easily be broken by resting the skull on its base without the support of the mandible.

1. Refer to FIGURE 7.16.
2. Identify the **orbit**, the bony cavity protecting the eye, and observe that the **orbital margin** and walls are thickest laterally.
3. Observe that the **orbital margin** is formed by three bones (**frontal**, **maxilla**, and **zygomatic**).
4. Superior to the orbit, identify the **frontal bone** and observe that it extends superiorly to form the bony support of the forehead and posteroinferiorly to form the roof of the orbit.
5. Identify the **superciliary arch**, a thickened ridge along the superior margin of the orbit.
6. Observe that right and left superciliary arches contain the **supraorbital notch (foramen)** and are separated by a small depression, the **glabella**.
7. Inferior to the glabella, identify the **nasion**, the junction between the frontal and **nasal bones**.

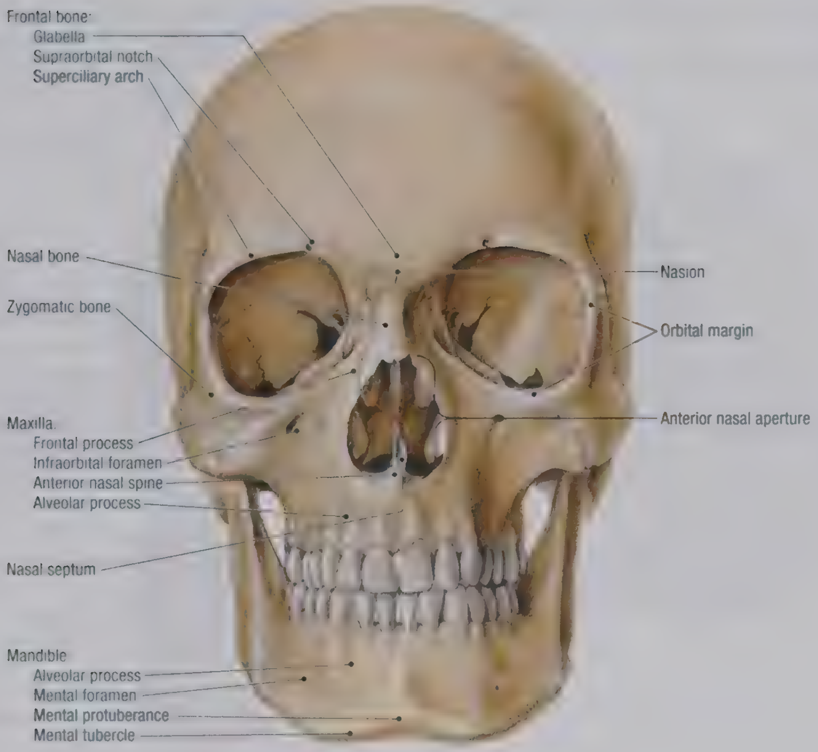

Frontal bone:
Glabella
Supraorbital notch
Superciliary arch
Nasal bone
Zygomatic bone
Maxilla:
Frontal process
Infraorbital foramen
Anterior nasal spine
Alveolar process
Nasal septum
Mandible
Alveolar process
Mental foramen
Mental protuberance
Mental tubercle
Nasion
Orbital margin
Anterior nasal aperture

FIGURE 7.16 ● The skull. Anterior view.

8. Observe that the right and left **nasal bones** form the superior extent of the bridge of the nose.
9. Posterior to the nasal bones, identify the thin **frontal process of the maxilla** extending superiorly to the frontal bone.
10. On the anterior surface of the maxilla, identify the **infraorbital foramen** and the **alveolar processes**, the thickened ridges corresponding to the attachment sites for the upper dentition (upper teeth).
11. In the midline where the maxillae meet, identify the small bony projection of the **anterior nasal spine**, oriented anterior and inferior to the **nasal septum**.
12. Observe that the **anterior nasal aperture** is bounded by the nasal bones and maxillae.
13. Lateral to the maxillae, near the region of the cheek, identify the right and left **zygomatic bones**.
14. Identify the **mandible**, the jaw, and observe that it has **alveolar processes** for the lower dentition (lower teeth).
15. In the midline of the mandible, identify the **mental protuberance**, the thickened ridge marking the fusion point of the right and left portions of the mandible during development.
16. Observe that the shape of a person's chin is related to the shape of the mental protuberance and the bilaterally located ridge-like **mental tubercles** located to either side of the protuberance.
17. On the anterior surface of the mandible, identify the bilateral openings of the **mental foramen**.
18. Observe that the mental foramen is almost in a direct line with the infraorbital foramen and the supraorbital foramen, the exit points of the cutaneous branches of the trigeminal nerve, which, in addition to other functions, provides sensory innervation to the face.

### *Lateral View of the Skull*

ATLAS 7.3

1. Refer to FIGURE 7.17.
2. Posterior to the **frontal bone**, identify the paired **parietal bones**. Observe that a parietal bone is relatively smooth with the exception of the **superior temporal line** and **inferior temporal line**, which demarcate the superior attachment of a large muscle of mastication, the temporalis.

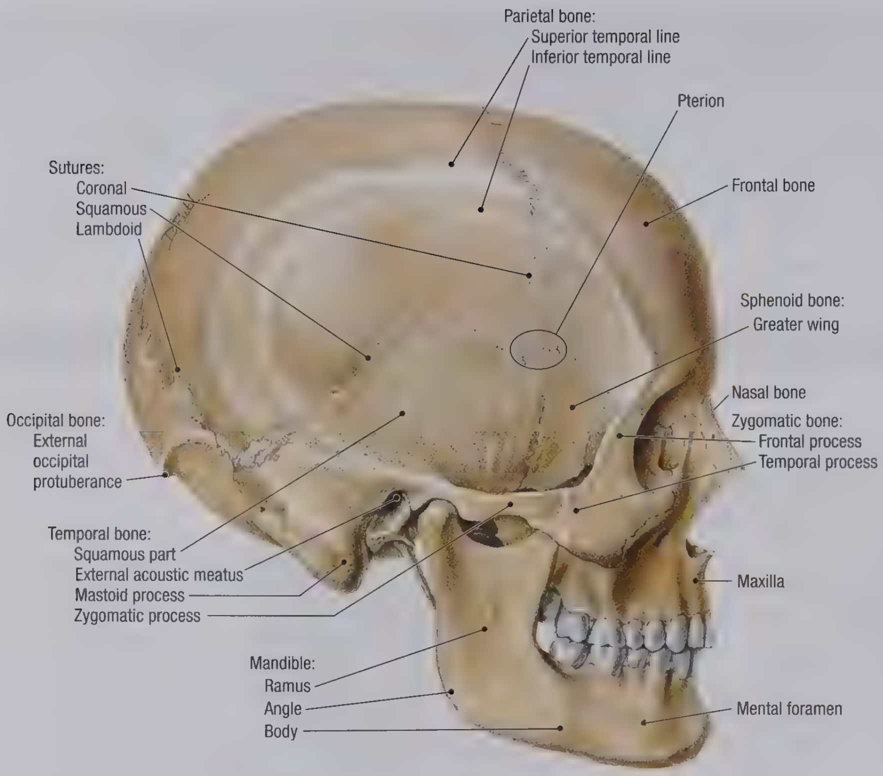

Parietal bone:
Superior temporal line
Inferior temporal line
Pterion
Frontal bone
Sutures:
Coronal
Squamous
Lambdoid
Sphenoid bone:
Greater wing
Nasal bone
Zygomatic bone:
Frontal process
Temporal process
Occipital bone:
External occipital protuberance
Temporal bone:
Squamous part
External acoustic meatus
Mastoid process
Zygomatic process
Maxilla
Mandible:
Ramus
Angle
Body
Mental foramen

FIGURE 7.17 ● The skull. Lateral view.

3. Identify the **sutures** of the skull, the immobile fibrous joints located along the edges of the bones of the skull where they meet.
4. Observe that the parietal bones articulate anteriorly with the frontal bone along the **coronal suture** and posteriorly with the occipital bone along the **lambdoid (lambdoidal) suture**.
5. On the posterior aspect of the skull, identify the **external occipital protuberance** along the midline of the **occipital bone**. The portion of the occipital bone that extends anteriorly along the base of the skull will be studied at a later time.
6. On the lateral aspect of the skull, identify the **temporal bone**. Observe that the temporal bone meets the parietal bone nearly along the entire length of the flat part of the bone, the **squamous part**, along the **squamous (squamosal) suture**. The other portion of the temporal bone, the "rocklike" petrous part, extends into the cranial cavity and will be seen later.
7. On the lateral aspect of the temporal bone, identify the opening of the **external acoustic meatus** anterior to the large bony extension of the **mastoid process** and posterior to the **zygomatic process** extending toward the zygomatic bone.
8. Observe that the zygomatic process of the temporal bone meets the **temporal process** of the **zygomatic bone** to form the **zygomatic arch**. *Note that the processes forming the arch are named for the bone they are directed at and not the bone from which they originate.*
9. Observe that the zygomatic bone has a vertically oriented **frontal process**, named for its extension toward, and articulation with, the frontal bone.
10. In the depression of the "temple," identify the **greater wing of the sphenoid bone**.
11. Superior to the greater wing of the sphenoid, identify the **pterion**, the junction of the frontal bone, parietal bone, greater wing of sphenoid bone, and squamous part of the temporal bone. *Note that the pterion is of clinical importance because it is a common site of fracture putting the patient at risk of hemorrhage because it overlies a key artery inside the skull.*

12. From a lateral perspective, observe that the **mandible** has a **ramus** (vertical portion) and a **body** (horizontal portion), which are differentiated by the **angle**.
13. Follow the **base (inferior border)** of the mandibular body anteriorly and confirm that the **mental foramen** is visible from the lateral perspective.

### *Superior View of the Skull*

ATLAS 7.4B

1. Refer to FIGURE 7.18.
2. Identify the **calvaria**, the "skull cap," formed by parts of the frontal, parietal, and occipital bones connected through sutures.
3. Observe that the **coronal suture**, the suture between the frontal bone and the two parietal bones, is perpendicular to the **sagittal suture**, which lies between the two parietal bones. The **bregma** is the point where the sagittal and coronal sutures meet.
4. On the posterior aspect of the calvaria, identify the **lambdoid suture** between the occipital bone and the two parietal bones and the **lambda**, the point where the sagittal and lambdoid sutures meet.
5. Observe that most of the sutures of the calvaria are readily identifiable; however, the **frontal (metopic) suture**, which forms between the ossification centers of the paired frontal bones, is usually not seen in the adult.

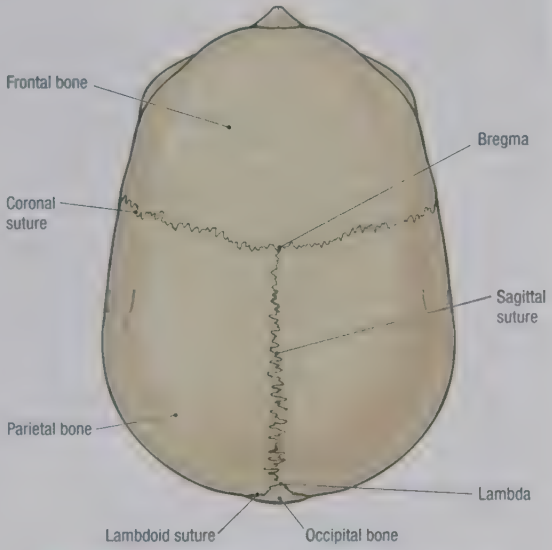

Frontal bone
Bregma
Coronal suture
Sagittal suture
Parietal bone
Lambda
Lambdoid suture
Occipital bone

FIGURE 7.18 ● Calvaria of the skull. Superior view.

## Surface Anatomy

### *Face*

ATLAS 7.69A, 7.69B

The surface anatomy of the face may be studied on a living subject or on a cadaver. On the cadaver, fixation may make it difficult to distinguish bone from well-preserved soft tissues.

1. Refer to FIGURE 7.19.
2. Place the cadaver in the supine (face up) position.
3. Palpate the **vertex** of the head, the most superior aspect.
4. Superior to the orbit, palpate the **supraorbital margin** and make an effort to identify the location of the **supraorbital notch**.
5. Observe that the eyes are protected by thin extensions of skin over their anterior surfaces, the **upper** and **lower eyelids**.
6. Along the superior aspect of the nose, palpate the transitions between the **nasal bones** and the **nasal cartilage**.
7. Work your fingers inferiorly from the midline of the nose toward the lips and identify the **philtrum**, the small depression superior to the **upper lip**.
8. Inferior to the **lower lip** at the chin, palpate from the **mental protuberance of the mandible** along the **body of the mandible** to the **angle of the mandible**.
9. Palpate the **zygomatic bone** at the cheeks and palpate posterolaterally along the **zygomatic arch** toward the external ear.

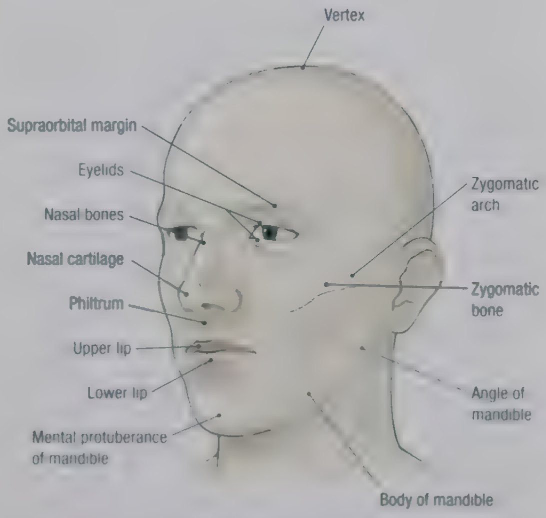

Vertex
Supraorbital margin
Eyelids
Nasal bones
Nasal cartilage
Philtrum
Upper lip
Lower lip
Mental protuberance of mandible
Zygomatic arch
Zygomatic bone
Angle of mandible
Body of mandible

FIGURE 7.19 ● Surface anatomy of the face. Left anterolateral view.

## Dissection Instructions

### Skin Incisions of the Face

VIDEO 7.5.1

***Dissection Note:*** The skin of the face is very thin and firmly attached to the cartilage of the nose and ears, but it is mobile over other parts of the face. The muscles of facial expression are attached to the skin superficially and the bones of the skull deeply. While making the skin incisions of the face, care must be taken to not cut too deeply and thus damage the underlying structures.

1. Refer to FIGURE 7.20.
2. In the midline, make a shallow (2 mm) skin incision that begins near the vertex (A) that passes inferiorly through the hairline and forehead to the nasion (B).
3. From the nasion, continue the midline incision inferiorly along the bridge of the nose to a point just superior to the upper lip at the philtrum.
4. Encircle the mouth at the margin of the upper and lower lips.
5. Make a midline incision from the inferior border of the lower lip to the mental protuberance (C).
6. Make an incision from the mental protuberance (C) along the inferior border of the mandible to a point just superior to the angle of the mandible. *Note that if the neck was previously dissected, this incision has already been made.*
7. On the lateral surface of the head, make a skin incision from the vertex (A) toward the upper part of the ear (D).

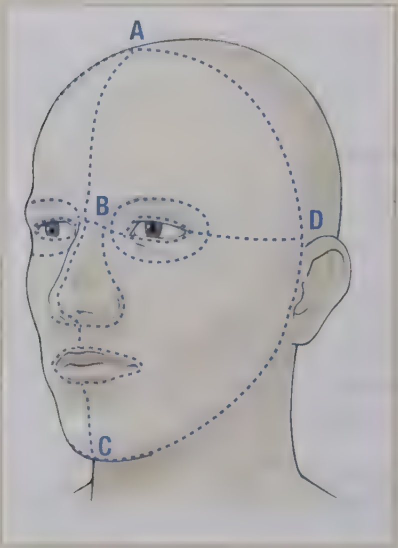


FIGURE 7.20 ● Skin incisions of the face. Left anterolateral view.

8. Continue the incision inferiorly from the lateral aspect of the head (D) by passing anterior to the ear toward the angle of the mandible to connect with the horizontal incision along the margin of the mandible.
9. Starting at the nasion (B), carefully make a shallow incision that encircles the orbital margin. *Do not yet remove the skin overlying the eyelids because this will be removed later.*
10. Extend the incision from the lateral angle of the eye to the incision near the ear (D).
11. Beginning at the midline, remove the skin of the forehead making an effort to leave the connective tissue intact and to not remove the thin frontalis muscle with the skin. *Note that the skin of the region adheres tightly to the tough subcutaneous connective tissue and sharp dissection may be required.*
12. Remove the skin of the lower face, beginning at the midline and proceeding laterally, observing that the superficial fascia of the face is thick and contains the muscles of facial expression.
13. Detach the skin laterally and place it in the tissue container.

### Superficial Fascia of the Face and the Facial Nerve

ATLAS 7.13, 7.15B; VIDEO 7.5.2

***Dissection Note:*** Because the deeper dissection of the face will take place on the right side of the cadaver, make special effort to clearly identify the following superficial structures on the left side of the face.

1. Refer to FIGURE 7.21.
2. Observe that the superior part of the **platysma muscle** extends into the face along the inferior border of the mandible. Recall that the inferior attachment of the platysma muscle is the superficial fascia of the upper thorax and that it forms a sheet of muscle covering the anterior neck.
3. Use blunt dissection to define the superior attachment of the platysma muscle on the inferior border of the mandible, skin of the cheek, and angle of the mouth.
4. Identify the **masseter muscle** on the lateral aspect of the face near the angle of the mandible. The masseter is a large muscle of mastication, not facial expression, and will be cleaned at a later stage in the dissection.
5. Identify the **parotid duct** where it crosses the lateral surface of the masseter muscle about 2 cm inferior to the zygomatic arch. *Note that the parotid duct is larger than the nearby nerves, approximately the diameter of a probe handle.*
6. Use blunt dissection to follow the parotid duct anteriorly just past the anterior border of the masseter muscle where the duct turns medially into the cheek

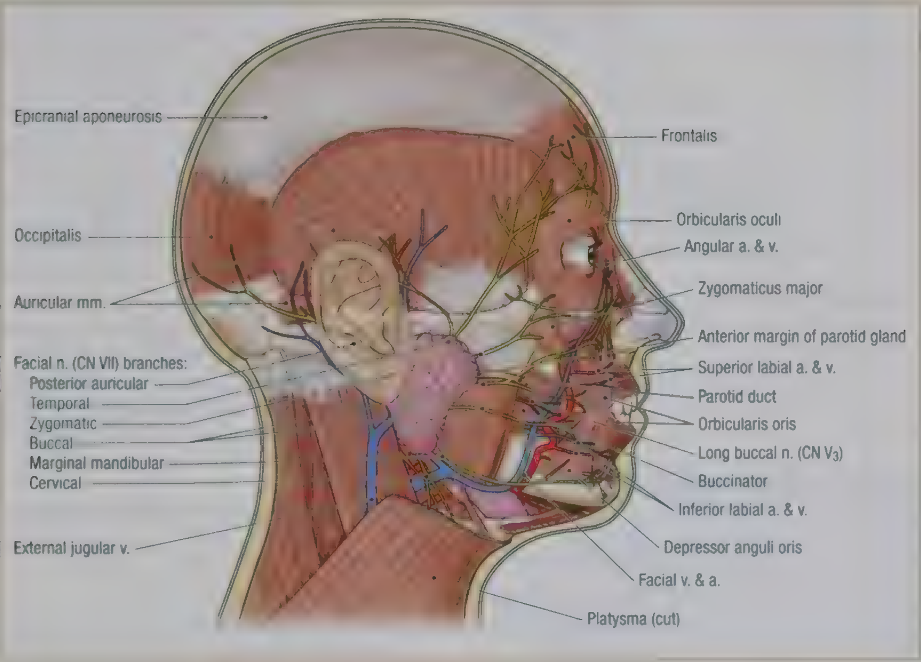

Epicranial aponeurosis
Occipitalis
Auricular mm.
Facial n. (CN VII) branches:
Posterior auricular
Temporal
Zygomatic
Buccal
Marginal mandibular
Cervical
External jugular v.
Frontalis
Orbicularis oculi
Angular a. & v.
Zygomaticus major
Anterior margin of parotid gland
Superior labial a. & v.
Parotid duct
Orbicularis oris
Long buccal n. (CN $V_3$)
Buccinator
Inferior labial a. & v.
Depressor anguli oris
Facial v. & a.
Platysma (cut)

FIGURE 7.21 ■ Superficial dissection of the face. Right lateral view.

to pierce the **buccinator muscle**. Clean the portion of the parotid duct lateral to the masseter muscle, the remaining anterior portion of the duct will be cleaned at a later stage in the dissection. *Note that the parotid duct drains into the oral vestibule lateral to the 2nd maxillary molar tooth.*

7. Use blunt dissection to follow the parotid duct posteriorly and identify the anterior margin of the **parotid gland**. *Note that in some individuals, an accessory parotid gland is present, which courses anteriorly along the parotid duct.*
8. Observe that the parotid gland is enclosed within the **parotid sheath**. *Note that the parotid sheath and the stroma of the parotid gland (connective tissue, blood vessels, nerves, and ducts) are continuous with the investing layer of the deep cervical fascia.*

***Dissection Note:*** The tough connective tissue surrounding the parotid gland will not yield to blunt dissection, thus scissors or the tip of the scalpel are recommended to remove this layer.

9. On the cadaver, identify a **buccal branch of the facial nerve** coursing parallel to the parotid duct. *Note that the buccal branch is typically not isolated but rather contains multiple branches coursing toward the cheek.*
10. Use blunt dissection to follow a buccal branch into the parotid gland, removing the parotid tissue superficial to the nerve piece by piece. Within the parotid gland, the nerve will join other facial nerve branches to form the **parotid plexus**.
11. From the parotid plexus, follow the other branches peripherally (toward the facial muscles) beginning superiorly with the **temporal** branch, which crosses the zygomatic arch.
12. Between the temporal branch and buccal branch, identify the **zygomatic branch** crossing the zygomatic bone.
13. Inferior to the buccal branch, identify the **mandibular branch** coursing parallel to the inferior margin of the mandible, and the **cervical branch** crossing the angle of the mandible to enter the neck.
14. Last, make a brief effort to identify the **posterior auricular** branch of the facial nerve, which passes posterior to the ear. *Note that the posterior auricular branch is often difficult to find because it is the first branch to emerge from the stylomastoid foramen and courses deep to the external ear.*
15. Follow the parotid plexus branches posteriorly and deeply (below the ear lobe) until they combine to form a single nerve, the **facial nerve (CN VII)**. *Note that the facial nerve emerges from the base of the skull through the stylomastoid foramen in the temporal bone. Do not attempt to follow the facial nerve to the foramen at this time.*

16. Define the anterior border of the masseter muscle while preserving the parotid duct and branches of the facial nerve.
17. Anterior to the masseter muscle, identify the **buccal fat pad**.
18. Use blunt dissection to remove the buccal fat pad and expose the **buccinator muscle**. Verify that the **parotid duct** pierces the buccinator muscle.
19. Coursing on the lateral surface of the buccinator, identify the **buccal (long buccal) nerve**, a branch of the mandibular division of the trigeminal nerve (CN $V_3$) emerging from deep to the masseter muscle. *Note that the buccal nerve is a sensory nerve that pierces the buccinator muscle to provide sensory innervation to the mucosa and skin of the cheek. Recall that motor innervation to the buccinator muscle was provided by the buccal branch of the facial nerve.*

CLINICAL CORRELATION

**Bell's Palsy**

ATLAS 7.16, 9.22C

Bell's Palsy, idiopathic facial paralysis, is the sudden loss of control of the muscles of facial expression, usually on one side of the face. The exact cause of Bell's palsy is unknown, but is believed to be associated with a virus, including inflammation and swelling around the facial nerve which controls the muscles of facial expression. The patient presents with drooping of the mouth and an inability to close the eyelid on the affected side.

## Facial Artery and Vein

ATLAS 7.12, 7.18B, 7.19; VIDEO 7.5.3

***Dissection Note:*** The facial artery and vein follow a winding course across the face and may pass either superficial or deep to the muscles of facial expression.

1. Refer to FIGURE 7.21.
2. Find the **facial artery** where it crosses the inferior border of the mandible at the anterior border of the masseter muscle.
3. Observe that the facial artery is more tortuous and usually located anterior to the facial vein. *Note that at this location, the facial artery and vein are covered only by the platysma muscle and skin.*
4. On the right side of the face, if not already done, cut the platysma muscle along the inferior border of the mandible while preserving the facial vessels. Detach the platysma from the angle of the mouth and place it in the tissue container.
5. Follow the facial artery inferiorly to the point where it passes deep to the submandibular gland in the neck where it crosses the inferior border of the mandible.
6. Follow the facial vein inferiorly observing that it passes superficial to the submandibular gland in the neck. The facial vein may have been cut when a portion of the gland was removed earlier.
7. Use blunt dissection to trace the facial artery superiorly toward the angle of the mouth and identify the **inferior labial** and **superior labial arteries** arising from it.
8. Continue to trace the facial artery superiorly as far as the lateral side of the nose, where its name changes to **angular** artery, and observe that the facial artery has several loops or bends in this part of its course.
9. Observe that the facial vein receives tributaries corresponding to the branches of the facial artery including the **superior** and **inferior labial veins** and the **angular vein**. *Note that the angular vein has a clinically important anastomotic connection with the ophthalmic veins in the orbit, which will be described when the orbit is dissected.*

## Muscles Around the Orbital Opening

ATLAS 7.12, 7.15A, 7.16; VIDEO 7.5.4

1. Refer to FIGURE 7.22.
2. Carefully remove the skin of the upper and lower eyelids taking particular care as the skin of the eyelids is the thinnest skin in the body at only 1 to 2 mm in thickness.
3. Identify the **orbicularis oculi muscle** encircling the **palpebral fissure**, the opening of between the eyelids.
4. Identify the **orbital part** of the orbicularis oculi muscle surrounding the orbital margin, the more peripherally located portion responsible for the tight closure of the eyelid.
5. Identify the **palpebral part** of the orbicularis oculi muscle, the thinner more centrally located portion contained in the eyelids responsible for blinking.
6. Review the attachments and actions of the orbicularis oculi muscle (see **TABLE 7.4**).

## Muscles Around the Oral Opening

ATLAS 7.12, 7.15A, 7.16; VIDEO 7.5.5

***Dissection Note:*** Several muscles alter the shape of the mouth and lips. Delineating the boundaries of the muscles of facial expression in this region is often difficult, and care must be taken to avoid damage to these thin muscles.

1. Refer to FIGURE 7.22.
2. Identify the **orbicularis oris muscle** (both superior and inferior portions), which surrounds the opening of the oral cavity.
3. Use blunt dissection to define the borders of the **zygomaticus major** and **minor muscles** angling from the corner of the mouth toward the zygomatic bone of the cheek. *Note that the zygomaticus major is typically larger and more laterally and inferiorly located.*

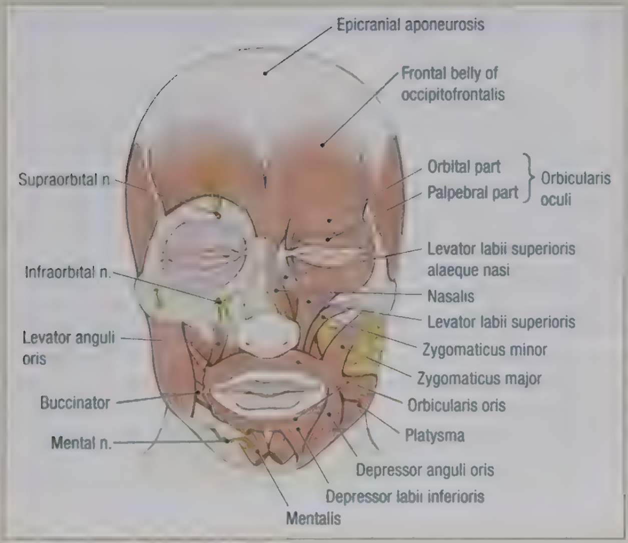

Epicranial aponeurosis
Frontal belly of occipitofrontalis
Supraorbital n.
Orbital part
Palpebral part
Orbicularis oculi
Levator labii superioris alaeque nasi
Infraorbital n.
Nasalis
Levator labii superioris
Levator anguli oris
Zygomaticus minor
Zygomaticus major
Buccinator
Orbicularis oris
Mental n.
Platysma
Depressor anguli oris
Depressor labii inferioris
Mentalis

FIGURE 7.22 ● Muscles of facial expression. Anterior view.

4. Superior to the upper lip, use blunt dissection to define the borders of the **levator labii superioris muscle** and the extension of muscle tissue coursing along the lateral aspect of the nose, the **levator labii superioris alaeque nasi muscle**.
5. Identify the **levator anguli oris** attaching near the angle of the mouth medial and somewhat deep to the medial aspect of the zygomaticus major.
6. Inferior to the lower lip, use blunt dissection to define the borders of the **depressor anguli oris muscle** and the **depressor labii inferioris muscle**.
7. Open the oral cavity and palpate the thickness of the **buccinator muscle** lining the cheek. Recall that the buccinator muscle is a muscle of facial expression and contributes to the actions of whistling, sucking, and blowing, and assists mastication by providing tension to hold food between the teeth.
8. Review the attachments, actions, and innervations of the muscles of facial expression (see **TABLE 7.4**).

## Sensory Nerves of the Face

ATLAS 7.16, 7.17; VIDEO 7.5.6

1. Refer to FIGURE 7.22 and FIGURE 7.23.
2. Observe that three branches of the trigeminal nerve supply sensory innervation to the face.
3. Identify the location of the **supraorbital nerve**, a branch of the ophthalmic division of the trigeminal nerve (CN $V_1$), which passes through the supraorbital notch (foramen) of the frontal bone to reach the skin above the eye. *Note that the supraorbital nerve lies deep to the frontal belly of the occipitofrontalis muscle and will be seen in the cadaver when the scalp is studied.*

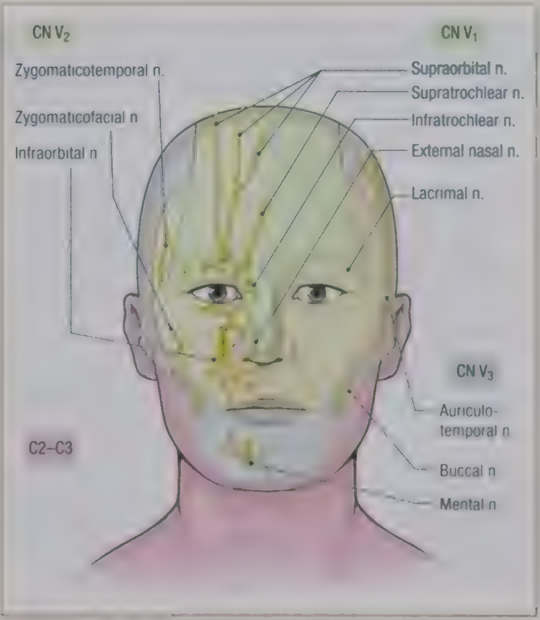

CN $V_2$
CN $V_1$
Zygomaticotemporal n.
Supraorbital n.
Supratrochlear n.
Zygomaticofacial n
Infratrochlear n.
Infraorbital n
External nasal n.
Lacrimal n.
CN $V_3$
Auriculo-temporal n
C2–C3
Buccal n
Mental n

FIGURE 7.23 ● Cutaneous nerves of the face. Anterior view.

4. Identify the location of the **infraorbital nerve**, a branch of the maxillary division of the trigeminal nerve (CN V$_2$), which passes through the infraorbital foramen of the maxilla deep to the levator labii superioris muscle. *Note that the infraorbital nerve supplies sensory innervation to the inferior eyelid, side of the nose, and upper lip.*
5. On the right side of the face, use blunt dissection to define the borders of the levator labii superioris muscle.
6. Transect the levator labii superioris muscle close to the infraorbital margin and reflect it inferiorly to expose the infraorbital nerve.
7. Observe that the **infraorbital artery** and **vein** also emerge from the infraorbital foramen.
8. Identify the location of the **mental nerve**, a branch of the mandibular division of the trigeminal nerve (CN V$_3$), emerges from the mental foramen of the mandible deep to the depressor anguli oris muscle. *Note that the mental nerve supplies sensory innervation to the skin of the lower lip and chin and the gingiva on alveolar ridge of anterior mandible.*
9. On the right side of the face, use blunt dissection to define the borders of the depressor anguli oris muscle.
10. Transect the depressor anguli oris muscle near the angle of the mouth and reflect it inferiorly to expose the mental nerve.
11. Observe that the **mental artery** and **vein** also emerge from the mental foramen.
12. Several smaller branches of the trigeminal nerve (**lacrimal**, **infratrochlear**, **zygomaticofacial**, **zygomaticotemporal**, and **external nasal**) also innervate the facial region. Do not attempt to dissect these small branches at this time.

## Dissection Follow-up

1. Review the path of the branches of the facial nerve from the parotid plexus to the muscles of facial expression.
2. Review the attachments, action, and innervation of the muscles of facial expression in **TABLE 7.4**.
3. Use a skull and the dissected specimen to review the branches of the trigeminal nerve that were dissected and the openings in the bones that they pass through.
4. Review the origin and course of the facial artery and vein as well as their branches and tributaries.
5. Replace the reflected muscles and tissues of the face back in their correct anatomical position.

**TABLE 7.4 | Main Muscles of Facial Expression**

| *Muscle* | *Medial Attachments* | *Lateral Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Orbicularis oculi | Medial orbital margin, medial palpebral ligament, and lacrimal bone | Skin around the orbital margin | Tightly closes the eye (orbital part)<br>Blinking (palpebral part) | Facial n. (CN VII) |
| Levator labii superioris | Upper lip (inferior attachment) | Maxilla just below the orbital margin (superior attachment) | Elevates upper lip | |
| Zygomaticus major | Angle of the mouth | Zygomatic bone | Draws angle of mouth superiorly and posteriorly | |
| Orbicularis oris | Maxilla, mandible, and skin in the median plane | Angle of the mouth | Sphincter of the mouth | |
| Buccinator | Angle of the mouth | Pterygomandibular raphe and the lateral surfaces of the alveolar processes of the maxilla and mandible | Compresses cheek against molar teeth, keeping food on the occlusal surfaces during chewing | |
| Depressor anguli oris | Angle of the mouth | Mandible | Depresses the angle of the mouth | |
| Depressor labii inferioris | Lower lip (superior attachment) | | Depresses lower lip | |

Abbreviations: CN, cranial nerve; n., nerve.

# PAROTID REGION

## Dissection Overview

The parotid region is the area on the side of the face anterior to the ear and inferior to the zygomatic arch. The parotid bed is the area occupied by the parotid gland. The parotid gland surrounds the posterior edge of the ramus of the mandible and therefore is in close contact with nerves, vessels, muscles, bones, and ligaments in the region. The superficial portion of the parotid gland was removed to expose the branches of the facial nerve. The goal of this dissection is to remove the remainder of the parotid gland piece by piece, preserving the nerves and vessels that pass through it.

The order of dissection will be as follows: The branches of the facial nerve will be reviewed and followed posteriorly toward the stylomastoid foramen. The motor root of the facial nerve will be transected near the lobe of the ear and the parotid plexus, and its branches will be reflected anteriorly. The retromandibular vein will then be followed superiorly through the parotid gland as the parotid tissue that lies superficial to it is removed. The external carotid artery will then be followed superiorly as additional parotid tissue is removed.

### Skeletal Anatomy

Refer to a skeleton or disarticulated skull to identify the following skeletal features.

#### *Temporal Bone and Mandible*

ATLAS 7.48

***Dissection Note:*** Recall that the small bony projections (processes) extending from the inferior surface of the skull can easily be broken by resting the skull on its base without the support of the mandible.

1. Refer to FIGURE 7.24.
2. Identify the opening of the **external acoustic meatus** on the lateral aspect of the temporal bone, the depression aligned with the outer ear.
3. Anterior to the external acoustic meatus, identify the depression of the **mandibular fossa** on the inferior aspect of the temporal bone. If a mandible is present, articulate it with the base of the skull and observe that the mandibular fossa serves as the socket for the **temporomandibular joint (TMJ)**.
4. Medial to the mandibular fossa, identify the **styloid process**, a thin bony extension named for its pen-like "stylus" appearance descending from the base of the skull.
5. Posterior to the external acoustic meatus, and posterolateral to the styloid process, identify the large round mass of the **mastoid process**.
6. Between the styloid and mastoid processes, identify the **stylomastoid foramen**, the exit point of the facial nerve (CN VII) at the base of the skull.
7. On the mandible, review the location of the **head**, **neck**, **ramus**, **angle**, and **body**.

#### *Boundaries of the Parotid Bed*

ATLAS 7.47

Refer to a skull with an articulated mandible and an illustration to identify the boundaries of the parotid bed.

1. Refer to FIGURE 7.24.
2. Identify the posterior boundary formed by the **mastoid process** and posterior belly of the digastric muscle.
3. Identify the anterior boundary formed by the medial pterygoid muscle, the **ramus of the mandible**, and masseter muscle.
4. Identify the medial boundary formed by the **styloid process** and associated muscles (stylopharyngeus, styloglossus, and stylohyoid).
5. Identify the posterosuperior boundary formed by the floor of the **external acoustic meatus**.

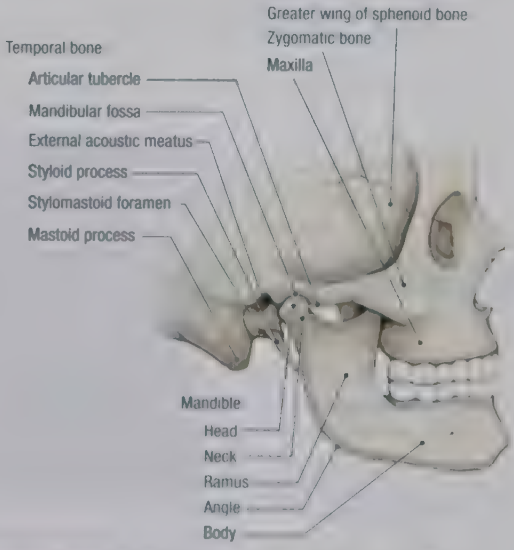


FIGURE 7.24 ■ Skeleton of the parotid region. Right lateral view.

# Dissection Instructions

## Parotid Region

ATLAS 7.47; VIDEO 7.6.1

***Dissection Note:*** Perform the following dissection steps on only the right side of the head. Preserve the superficial structures on the left side of the head for review.

1. Refer to FIGURE 7.25.
2. Identify the **great auricular nerve** where it crosses the SCM and note that it ends over the angle of the mandible. Detach the great auricular nerve superiorly and reflect it inferiorly off the surface of the SCM while leaving it attached to the cervical plexus.
3. Review the branches of the **facial nerve (CN VII)** previously dissected: **temporal**, **zygomatic**, **buccal**, **mandibular**, and **cervical**.
4. Trace the facial nerve branches posteriorly toward the parotid plexus and identify the two larger subdivisions of the plexus, the **temporofacial** and **cervicofacial divisions**.
5. Trace the divisions of the plexus toward the lobe of the ear and identify the main stem of the **motor root of the facial nerve**.
6. Cut the facial nerve as far posteriorly as possible, leaving a stump emerging from the stylomastoid foramen, and reflect the parotid plexus and all of its branches anteriorly.
7. Review the course of the **parotid duct**.
8. Make a vertical cut through the parotid gland to leave a portion of the gland attached to the parotid duct near where it exits the gland and reflect the duct and attached glandular tissue anteriorly leaving its passage through the buccinator muscle undisturbed.
9. Near the superior extent of the parotid gland, identify the **auriculotemporal nerve**, a branch of the mandibular division of the trigeminal nerve (CN $V_3$), which passed between the head of the mandible and the external acoustic meatus. *Note that as the auriculotemporal nerve passes through the parotid gland, it delivers postsynaptic parasympathetic nerve fibers from the otic ganglion.*
10. Follow the auriculotemporal nerve superiorly where it crosses the zygomatic process of the temporal bone alongside the **superficial temporal artery** and **vein** to reach the skin of the anterior side of the ear and temporal region.
11. In the neck, find the **external jugular vein**. Use blunt dissection to follow the external jugular vein superiorly to the point where it is formed by the joining of the **posterior auricular vein** and the **retromandibular vein**.
12. Use blunt dissection to follow the retromandibular vein superiorly into the parotid gland.
13. Trace the retromandibular vein to the point where it is formed by the joining of the **maxillary vein** and the **superficial temporal vein**, removing parotid tissue as you progress superiorly.
14. Follow the **superficial temporal vein** superiorly until it crosses the superficial surface of the zygomatic arch, continuing to remove the parotid gland as you proceed. Do not follow the maxillary vein at this time because it will be dissected later.
15. Return to the neck and find the **external carotid artery**. Use blunt dissection to follow the external

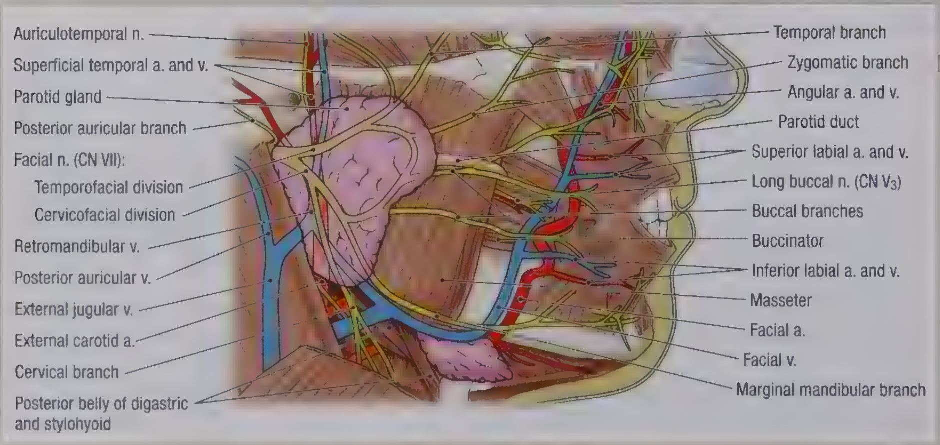

Auriculotemporal n.
Superficial temporal a. and v.
Parotid gland
Posterior auricular branch
Facial n. (CN VII):
Temporofacial division
Cervicofacial division
Retromandibular v.
Posterior auricular v.
External jugular v.
External carotid a.
Cervical branch
Posterior belly of digastric and stylohyoid
Temporal branch
Zygomatic branch
Angular a. and v.
Parotid duct
Superior labial a. and v.
Long buccal n. (CN V3)
Buccal branches
Buccinator
Inferior labial a. and v.
Masseter
Facial a.
Facial v.
Marginal mandibular branch

FIGURE 7.25 ● Parotid region. Right lateral view.

carotid artery superiorly as far as the angle of the mandible, removing the lower part of the parotid gland.

16. Verify that the external carotid artery passes superiorly along the posterior edge of the ramus of the mandible. *Note that near the neck of the mandible, the external carotid artery divides into its two terminal branches, the maxillary artery and the superficial temporal artery, although the terminal branches may not yet be visible as the retromandibular vein lies superficially.*
17. On the lateral aspect of the head, identify and clean the **superficial temporal artery** where it crosses the zygomatic process of the temporal bone just anterior to the external acoustic meatus. Observe that at this location, the superficial temporal artery is anterior to the auriculotemporal nerve.
18. Make an effort to clean and follow one or two of the branches of the superficial temporal artery, which distribute blood supply to the lateral part of the scalp. *Note that the branches of the superficial temporal artery are named according to their target region of distribution and include transverse facial, auricular, zygomatico-orbital, middle temporal, frontal, and parietal arterial branches.*
19. Remove any remaining parotid tissue from the zygomatic arch and lateral surface of the masseter muscle.
20. Follow the **posterior belly of the digastric muscle** and the **stylohyoid muscle** superiorly toward the base of the skull and clean away any parotid tissue that remains on their anterior borders or lateral surfaces. Expose the digastric muscle all the way to its attachment on the mastoid process.
21. Remove all remaining parotid tissue and the investing layer of deep cervical fascia that binds the SCM to deeper structures while preserving the posterior division of the retromandibular vein.

**CLINICAL CORRELATION**

### Parotidectomy

ATLAS 7.13

Swelling of the parotid gland (as occurs in mumps) may be quite painful due to the increased pressure on the parotid sheath irritating branches of the facial nerve including the great auricular nerve. The enlarged parotid gland pushes the ear lobe superiorly and laterally and may cause compression of the facial nerve along its course through the gland. During parotidectomy (surgical excision of the parotid gland), the facial nerve is in danger of being injured and the branches must carefully be avoided. If the facial nerve is damaged, the facial muscles will become paralyzed as seen in Bell's palsy.

## Dissection Follow-up

1. Review the boundaries of the parotid bed.
2. Review the course and branches of the facial nerve beginning at the internal acoustic meatus to the muscles of facial expression.
3. Review the superficial venous drainage of the lateral side of the head and neck, beginning with the superficial temporal veins and ending with the subclavian vein in the root of the neck.
4. Review the origin, course, and branches of the external carotid artery.
5. Replace the facial nerve in its correct anatomical position and approximate the cut ends.
6. Replace the parotid duct and any other reflected tissue in its correct anatomical position.

# SCALP

## Dissection Overview

The scalp consists of five layers. As an aid to memory, note that the first letters of the names of the five layers spell the word *scalp*. The first layer, or most superficial layer, of the scalp is the *Skin*. Deep to the skin, dense subcutaneous *Connective* tissue containing the vessels and nerves of the scalp forms the second layer. The third layer of the scalp is the *Aponeurosis* (epicranial aponeurosis) connecting the frontal belly to the occipital belly of the occipitofrontalis muscle. The first three layers of the scalp are tightly bound to each other and difficult to separate. Deep to the epicranial aponeurosis is the fourth layer formed by *Loose* connective tissue that permits the scalp to move over the skull. The fifth and last layer is the *Pericranium* or periosteum of the cranial bones.

The order of dissection will be as follows: The layers of the scalp will be reflected. The muscles of the scalp will be examined. The underlying neurovasculature of the scalp will be studied.

## Dissection Instructions

### Scalp

ATLAS 7.15B, 7.20; VIDEO 7.7.1

***Dissection Note:*** The following cuts may be made through the entire thickness of the scalp with the scalpel contacting the bone of the calvaria or through the initial three layers of the scalp only to approach the layers of the scalp sequentially.

1. Refer to FIGURE 7.26.
2. Make a midline cut from the nasion (B) through the vertex (A) to the external occipital protuberance (X). *If the face was previously dissected, a portion of this cut was already made.*
3. Make a cut in the coronal plane bilaterally from the vertex (A) to a point anterior to the ear (D). *If the face was previously dissected, a portion of this cut was made previously.*
4. Beginning at the vertex, use forceps to grasp one corner of the cut scalp.
5. If reflecting all layers at once, insert a chisel between the scalp and the calvaria. Use the chisel to loosen the scalp from the calvaria and raise the flaps of skin.
6. Once the flap of scalp is raised, grasp the flap with both hands and pull it inferiorly.
7. If reflecting the first three layers only, grasp the cut edge of skin and dense connective tissue and make an effort to separate them from the underlying aponeurosis. *Note that the separation of these layers is difficult as they are quite thin and firmly attached.*
8. Refer to FIGURE 7.27.
9. In either technique, reflect all four flaps of scalp down to the level that a hatband would occupy, but do not yet detach the flaps.
10. If all layers were cut and reflected together, examine the cut edge of the scalp and identify the **occipitofrontalis muscle**. *Note that the occipitofrontalis is a muscle of facial expression and innervated by branches of the facial nerve (CN VII).*
11. If the skin and connective tissue was reflected in isolation, identify the occipitofrontalis muscle on the superior aspect of the skull.
12. Observe that the occipitofrontalis muscle has two muscular bellies, **frontal** and **occipital**, connected over the vertex of the skull by the **epicranial aponeurosis**.
13. Observe that the inferior attachment of the occipital belly is the occipital bone and its superior attachment is the epicranial aponeurosis. Similarly, observe that the superior attachment of the frontal belly is the epicranial aponeurosis and its inferior attachment is the skin of the forehead and eyebrows.
14. If the skin and connective tissue was reflected in isolation, make cuts through the epicranial aponeurosis (**Cut 1**) paralleling the skin incision lines.
15. Reflect the four sections of muscular and aponeurotic tissue inferiorly to the same level as the reflected skin.

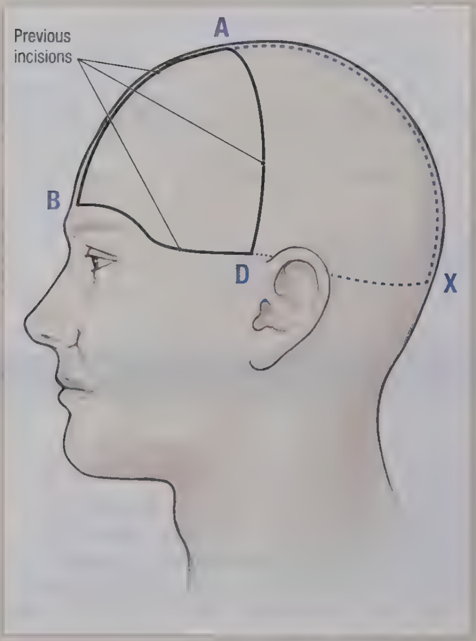


FIGURE 7.26 ■ Scalp incisions. Left lateral view.

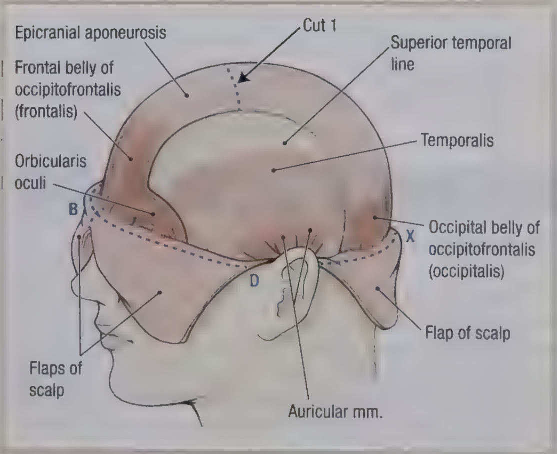


FIGURE 7.27 ■ Reflection of the scalp. Left lateral view.

CLINICAL CORRELATION

**Scalp Injuries and Infections**

ATLAS 7.20

The connective tissue layer of the scalp contains collagen fibers that attach to the external surface of the blood vessels. When the scalp is cut, the connective tissue holds the lumen of the vessels open preventing vasoconstriction resulting in profuse bleeding. If an infection or trauma occurs in the scalp, the associated pus and blood can easily spread within the loose connective tissue layer or "danger area." From the "danger area," the infection may pass into the cranial cavity through emissary veins to reach the meninges. The occipital belly of the occipitofrontalis muscle prevents spread of infection from the "danger area" into the neck posteriorly. As the frontal belly attaches to the skin of the forehead, an infection in the scalp may spread anteriorly into the eyelids or nose.

16. Refer to FIGURE 7.28.
17. Pull the anterior scalp flap and muscular tissue inferiorly to expose the supraorbital margin. Identify the **supraorbital nerve and vessels** where they exit the supraorbital notch and enter the deep surface of the scalp.
18. Observe that nerves and vessels are contained within the flaps of the scalp and enter the scalp from more inferior regions.
19. Pull the posterior scalp flap and muscular tissue inferiorly to expose the region of the external occipital protuberance.
20. On the lateral aspect of the head, make an effort to identify the **superficial temporal vessels** accompanying the **auriculotemporal nerve branches**.
21. Posterior to the ear, make an effort to identify the **posterior auricular vessels** accompanying the **lesser occipital nerve branches**.
22. On the posterior aspect of the head, make an effort to identify the **occipital vessels** accompanying the **greater occipital nerve branches**.
23. On the lateral surface of the calvaria, note that the scalp has separated from the fascia that covers the **temporalis muscle (temporal muscle)**.
24. Refer back to FIGURE 7.27.
25. Make a brief effort to identify the thin **auricular muscles** overlying the fascia of the temporalis muscle. Observe that if visible the auricular muscles often subdivide into anterior, superior, and posterior muscular bellies.
26. If the scalp and underlying muscles were reflected together, carefully separate the layers of the scalp superficial to the occipitofrontalis muscle and epicranial aponeurosis, making an effort to preserve the branches of the superficial temporal artery and auriculotemporal nerve.
27. Remove the superficial layers of the scalp (skin and dense connective tissue) from the dissection field by making horizontal incisions around the periphery of the head from the nasion (B) passing just above the ear (D) until you reach the external occipital protuberance (X) and place them in the tissue container. Take care to leave the muscular tissue layer intact.

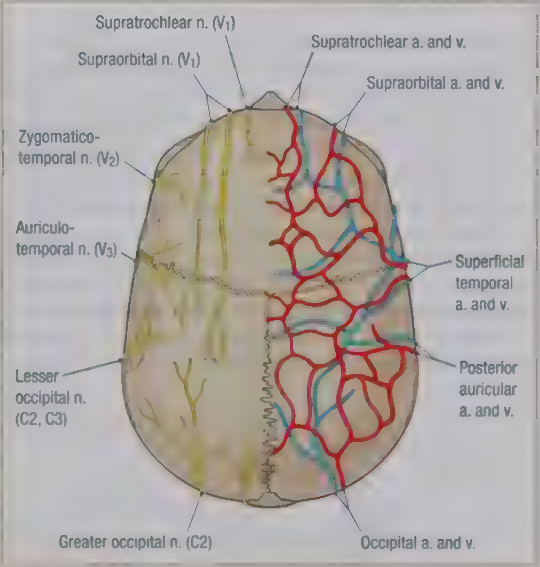

Supratrochlear n. ($V_1$)
Supratrochlear a. and v.
Supraorbital n. ($V_1$)
Supraorbital a. and v.
Zygomatico-temporal n. ($V_2$)
Auriculo-temporal n. ($V_3$)
Superficial temporal a. and v.
Lesser occipital n. (C2, C3)
Posterior auricular a. and v.
Greater occipital n. (C2)
Occipital a. and v.

FIGURE 7.28 ● Cutaneous nerves (left side) and blood vessels (right side) of the scalp. Superior view.

## Dissection Follow-up

1. Review the course of nerves and vessels that supply the scalp studying the paralleling neurovascular relationships.
2. Use a skull and the dissected specimen to review the course of the supraorbital nerve through the supraorbital notch.
3. Review the attachments and innervations of the occipitofrontalis muscle.
4. Replace the flaps of remaining scalp in their correct anatomical positions.

# TEMPORAL AND INFRATEMPORAL REGIONS

## Dissection Overview

The temporal region consists of two fossae: temporal and infratemporal. The temporal fossa is located superior to the zygomatic arch and contains the temporalis muscle. The infratemporal fossa is inferior to the zygomatic arch and deep to the ramus of the mandible. The infratemporal fossa contains the medial and lateral pterygoid muscles, branches of the mandibular division of the trigeminal nerve (CN $V_3$), and the maxillary vessels and their branches. The infratemporal and temporal fossae are in open communication with each other through the area between the zygomatic arch and the lateral surface of the skull.

The order of dissection will be as follows: The masseter muscle will be studied. The zygomatic arch will be detached and the masseter muscle will be reflected inferiorly while attached to a portion of the arch. The temporalis muscle will be studied. The coronoid process will be detached from the mandible, and the temporalis muscle will be reflected superiorly with the attached coronoid. The superior part of the ramus of the mandible will be removed, and the maxillary artery will be traced across the infratemporal fossa. The branches of the mandibular division of the trigeminal nerve will be dissected. The medial and lateral pterygoid muscles will be studied and the TMJ will be dissected.

### Skeletal Anatomy

Refer to a disarticulated mandible to identify the following skeletal features.

### *Mandible*

ATLAS 7.48B, 7.48E

1. Refer to FIGURE 7.29.
2. From a lateral view, review the location of the **ramus**, **angle**, and **body of the mandible**.
3. Follow the ramus of the mandible superiorly and identify the **head (mandibular condyle, condyloid process)**, the projection of bone located on the posterior and superior extent of the bone superior to the thinner **neck**.
4. Identify the **coronoid process**, the thinner "bladelike" projection of bone extending superiorly from the anterior portion of the ramus.
5. Observe that the two superior projections of bone, the coronoid and condyloid processes, are separated from one another by the **mandibular notch**.
6. Inferiorly along the body of the mandible, review the location of the **mental foramen** and **mental tubercle**.
7. On the internal surface of the ramus of the mandible, identify the small projection of the **lingula**, the inferior attachment site of the sphenomandibular ligament.
8. Posterior to the lingula, identify the opening of the **mandibular foramen**, a passage for the inferior alveolar nerves and vessels to the lower dentition.

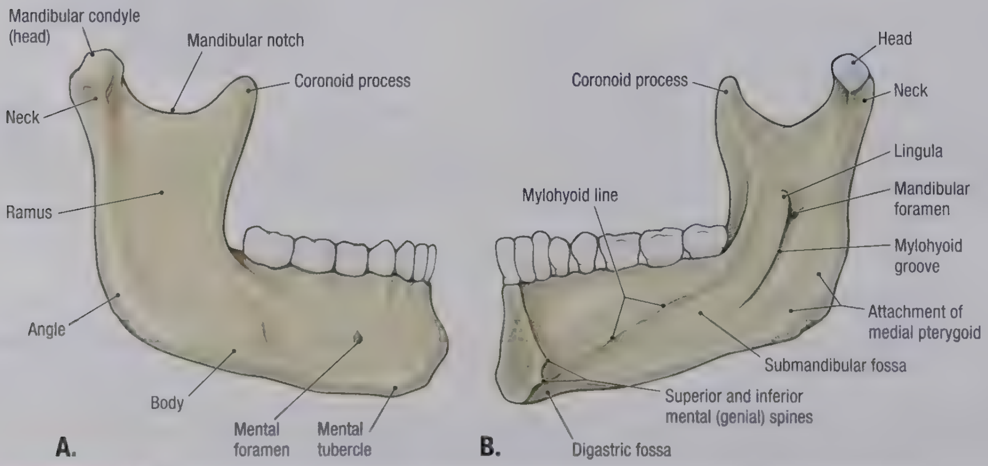

Mandibular condyle (head)
Mandibular notch
Coronoid process
Neck
Ramus
Angle
Body
Mental foramen
Mental tubercle
A.
Coronoid process
Head
Neck
Lingula
Mandibular foramen
Mylohyoid line
Mylohyoid groove
Attachment of medial pterygoid
Submandibular fossa
Superior and inferior mental (genial) spines
Digastric fossa
B.

FIGURE 7.29 External and internal features of the right side of the mandible. **A.** Right lateral view. **B.** Right medial view.

9. On the inner surface of the body of the mandible beginning at the mandibular foramen, identify the **mylohyoid groove**, a thin depression for the nerve to mylohyoid and mylohyoid vessels.
10. Identify the **mylohyoid line** slightly superior to the mylohyoid groove coursing anteriorly toward the small projections of bone near the midline of the mandible on its inner surface, the **superior** and **inferior mental spines (glenoid tubercles)**.
11. Inferior to the mylohyoid line, identify the depression of the **submandibular fossa** laterally and the **digastric fossa** more anteriorly.

## *Temporal and Infratemporal Fossae*

ATLAS 7.48A, 7.48D, 7.78A

***Dissection Note:*** Review the following skeletal features on a skull with the mandible removed.

1. Refer back to FIGURE 7.17.
2. From a lateral perspective, identify the **superior and inferior temporal lines** on the parietal bone.
3. Observe that the **temporal fossa** is formed by parts of four cranial bones: parietal, frontal, squamous part of temporal, and greater wing of sphenoid. Recall that the junction point of these bones forms the **pterion**.
4. Review that the **zygomatic arch** is formed by **the zygomatic process of the temporal bone** and the **temporal process of the zygomatic bone**.
5. Refer to FIGURE 7.30.
6. Review the location of the **mandibular fossa** and the **articular tubercle** on the temporal bone.
7. Deep to the zygomatic arch, identify the **pterygomaxillary fissure** between the **lateral pterygoid plate** of the sphenoid bone and the **maxilla**.
8. Carefully insert a thin wooden stick, or pipe cleaner, through the superior end of the pterygomaxillary fissure into the space of the **pterygopalatine fossa**.
9. On the medial wall of the pterygopalatine fossa, identify the opening of the **sphenopalatine foramen**. Carefully pass the pipe cleaner through the sphenopalatine foramen and observe from an anterior view that this opening connects the nasal cavity to the pterygopalatine fossa.

***Dissection Note:*** To reach the nasal cavity, structures from the infratemporal fossa will pass through a fissure (pterygomaxillary), a fossa (pterygopalatine), and a foramen (sphenopalatine).

10. Anterior to the pterygomaxillary fissure, observe that the maxilla has an **infratemporal surface** inferior to the **inferior orbital fissure**, a gap between the greater wing of the sphenoid bone and the maxilla. Pass the pipe cleaner through the inferior orbital fissure and observe that this opening connects the infratemporal fossa to the orbit.
11. From an inferior perspective, identify the **foramen ovale** and the **foramen spinosum** on the **greater wing of the sphenoid bone**.
12. Reposition the mandible on the skull and identify the **bony boundaries of the infratemporal fossa** beginning with the lateral boundary formed by the **ramus** of the mandible.
13. Observe that the infratemporal fossa has an anterior boundary formed by the **infratemporal surface of the maxilla** and a medial boundary formed by the **lateral pterygoid plate**.
14. Observe that the roof of the infratemporal fossa is formed by the **greater wing of the sphenoid bone** curving out laterally superior to the space.

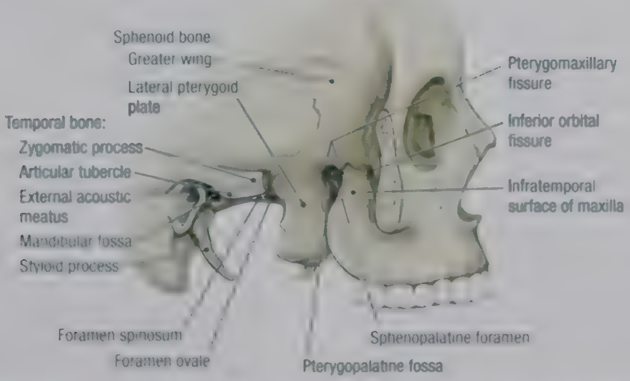


FIGURE 7.30 ■ Skeleton of the infratemporal region. Right lateral view.

# Dissection Instructions

## Masseter Muscle and Removal of the Zygomatic Arch

ATLAS 7.49, 7.53A; VIDEO 7.8.1

***Dissection Note:*** Perform the following dissection steps on only the right side of the head. Preserve the superficial structures on the left side of the head for review.

1. Refer back to FIGURE 7.25.
2. Reflect the cut **facial nerve** with its associated branches and the **parotid duct** anteriorly.
3. Clean the lateral surface of the **masseter** muscle and define its borders inferiorly along the ramus of the mandible and superiorly along the inferior border of the zygomatic arch.
4. Review the attachments and actions of the masseter muscle (see **TABLE 7.5**).
5. Review the course of the **superficial temporal vessels** and **auriculotemporal nerve** across the zygomatic arch.
6. Make a vertical incision through the temporal fascia overlying the temporalis muscle, and use blunt dissection to elevate a portion of the fascia from the surface of the muscle. Observe that the temporalis muscle is attached to the deep surface of the temporal fascia.
7. Cut through the temporal fascia along the superior temporal line and reflect it inferiorly. Because the temporalis is tightly adhered to the fascia, it may be necessary to use a scalpel to cut the fascia from the surface of the muscle.
8. Cut the temporal fascia along the superior border of the zygomatic arch to remove it from the dissection field.
9. Refer to FIGURE 7.31.
10. Near the anterior end of the zygomatic arch, insert a probe deep to the zygomatic arch as close to the orbit as possible. The probe should follow a slightly oblique path if inserted properly.
11. Use a saw to cut through the zygomatic bone along the oblique line paralleling the probe (**Cut 1**). *Wear eye protection for all steps that require the use of a bone saw.*
12. Insert the probe deep to the zygomatic arch near the anterior border of the head of the mandible.
13. Use a saw to cut through the zygomatic arch posteriorly in a line parallel to the probe (**Cut 2**).
14. Gently pull the masseter muscle and the attached portion of the zygomatic arch laterally and inferiorly and look for the masseteric vessels and nerve crossing superior to the mandibular notch, entering the deep surface of the masseter muscle.
15. Reflect the masseter and zygomatic arch in the inferior direction and cut through the masseteric nerve and vessels.

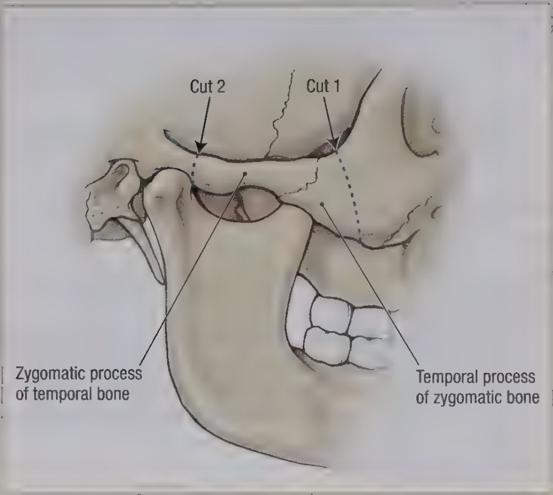

Cut 2
Cut 1
Zygomatic process of temporal bone
Temporal process of zygomatic bone

FIGURE 7.31 ■ Removal of the zygomatic arch. Right lateral view.

16. Use a scalpel to detach the masseter muscle from the superior part of the ramus of the mandible but leave the masseter muscle attached to the mandible near the angle.

## Temporal Region

ATLAS 7.49, 7.50, 7.53B; VIDEO 7.8.2

1. Refer back to FIGURE 7.21 and FIGURE 7.30.
2. Use a skull to review the skeletal boundaries of the temporal fossa.
3. On the right side of the cadaver, identify the **temporalis muscle.**
4. Remove the overlying fascia and connective tissue to clean the inferior attachment of the temporalis to the coronoid process of the mandible.
5. On the left side of the cadaver, observe that the **superficial boundary** of the temporal region is the **temporal fascia.**
6. Review the attachments and actions of the temporalis muscle (see **TABLE 7.5**).

## Infratemporal Fossa

ATLAS 7.50; VIDEO 7.8.3

***Dissection Note:*** Wear eye protection for all steps that require the use of the bone saw, chisel, or bone cutters.

1. Refer to FIGURE 7.32.
2. Gently insert a probe through the mandibular notch posterior to the temporalis tendon and push the probe anteroinferiorly toward the 3rd mandibular molar tooth. While advancing the probe, keep it in close contact with the deep surface of the mandible

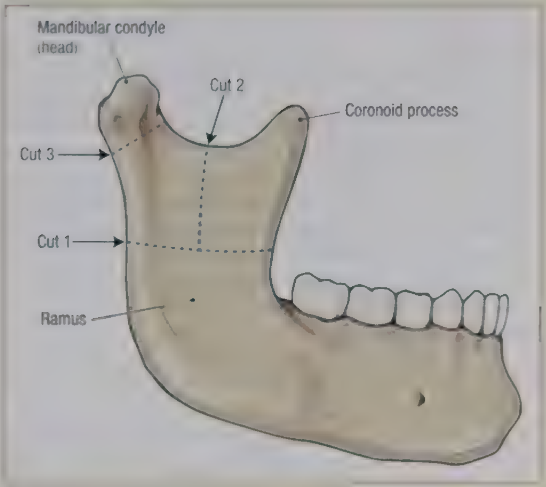


FIGURE 7.32 ● Removal of the superior aspect of the ramus of the mandible. Right lateral view.

to create separation from the underlying structures deep to the mandible.

3. Use a saw to score a line (cut halfway) horizontally through the ramus of the mandible just above the level of the lower dentition just near the midpoint of the ramus (**Cut 1**). *Wear eye protection for all steps that require the use of the bone saw, chisel, or bone cutters.*
4. Use a saw to score a line (cut halfway) vertically through the ramus of the mandible at the midpoint of the horizontal cut, which bisects the lowest point of the mandibular notch (**Cut 2**).

***Dissection Note:*** The two cuts through the ramus of the mandible should create an inverted "T"-shaped cut. Pay attention to not cut through the full depth of the bone while making the score lines.

5. Use bone cutters, or a chisel, to carefully break the bone along the score lines.
6. Insert a probe medial to the neck of the mandible and create separation between the underlying structures and the bone.
7. Use a saw to cut halfway through the neck of the mandible (**Cut 3**).
8. Use bone cutters to break the bone along the score line.
9. Refer to FIGURE 7.33.
10. Gently reflect the coronoid process, portions of the anterior superior corner of the ramus, and the attached temporalis muscle superiorly.
11. Use blunt dissection to release the temporalis muscle from the skull and observe that the **anterior** and **posterior deep temporal nerves** (branches of the mandibular division of the trigeminal nerve) and **arteries** enter the muscle from its deep surface. *Note that the deep temporal nerves, branches from CN $V_3$, provide motor innervation to the temporalis muscle.*
12. Deep to the mandible, identify the **inferior alveolar nerve** and **vessels**.

## CLINICAL CORRELATION

### Dental Anesthesia

ATLAS 7.50, 7.52

An inferior alveolar block is a commonly used method of providing dental anesthesia to the mandibular teeth. The needle is inserted through the oral mucosa near the opening of the mandibular foramen to anesthetize the lower dentition, oral mucosa, and lower lip innervated by the inferior alveolar nerve.

Similarly, a mandibular nerve block may be performed by injecting an anesthetic agent into the infratemporal fossa. A mandibular nerve block will anesthetize not only the inferior alveolar nerve but also the lingual, buccal, and possibly auriculotemporal nerves, resulting in anesthesia of the mandibular teeth, lower lip, chin, cheek, tongue, and TMJ.

13. Use bone cutters to carefully nibble away the superior posterior part of the mandible, beginning at the mandibular notch and proceeding inferiorly stopping at the level of the lingula.

***Dissection Note:*** While removing the bone, make small cuts and stop periodically to verify that you are staying on the lateral side of muscles, nerves, and vessels.

14. Remove the portions of bone superior to the horizontal score line and place it in the tissue container.
15. Clean the inferior alveolar nerve and artery and follow them inferiorly to the **mandibular foramen** to pass anteriorly in the **mandibular canal**. *Note that the inferior alveolar nerve provides sensory innervation to the mandibular teeth.*
16. Identify the **nerve to mylohyoid** arising from the posterior side of the inferior alveolar nerve just before it enters the mandibular foramen. *Note that the nerve to mylohyoid is a useful way to differentiate the inferior alveolar nerve from the nearby vessels.*
17. Near the chin, once again identify the **mental nerve** and recall that it is a branch of the inferior alveolar nerve, which passes through the mental foramen to innervate the chin and lower lip.
18. Medial to the cut ramus of the mandible, identify the **lingual nerve** just anterior to the inferior alveolar nerve and observe that it does not enter the mandibular foramen but remains medial to the mandible to pass medial to the 3rd mandibular molar. *Note that the lingual nerve provides sensory innervation to the mucosa of the anterior two-thirds of the tongue, the mucosa of the floor of the mouth, and the lingual alveolar mucosa.*

## Maxillary Artery

ATLAS 7.50, 7.51; VIDEO 7.8.4

1. Refer to FIGURE 7.33.
2. Identify the **maxillary artery** where it arises from the bifurcation of the external carotid artery.
3. Observe that the maxillary artery courses horizontally through the infratemporal fossa and crosses either the superficial surface (two-thirds of cases) or the deep surface (one-third of cases) of the lateral pterygoid muscle. *If the maxillary artery in your specimen passes deep to the lateral pterygoid muscle, it may be necessary to remove portions of the muscle while you identify the following branches of the maxillary artery.*
4. Use blunt dissection to trace the maxillary artery through the infratemporal fossa.
5. Near the point of origin of the maxillary artery from the external carotid artery, if visible, identify the **middle meningeal artery**. *Note that as the middle meningeal artery lies quite deep in the temporal fossa, it will be isolated at a later stage in the dissection.*
6. Identify and clean the **deep temporal arteries (anterior and posterior)**. Observe that deep temporal arteries arise from the superior aspect of the maxillary artery and pass superiorly and laterally across the roof of the infratemporal fossa at bone level to enter the deep surface of the temporalis muscle.
7. Identify and clean the remaining portion of the **masseteric artery** (cut in a previous dissection step). The masseteric artery courses laterally from the maxillary artery and passes through the mandibular notch to enter the deep surface of the masseter muscle.
8. Identify the **inferior alveolar artery** and follow it from where it entered the mandibular foramen with the inferior alveolar nerve inferiorly, back to its origin from the maxillary artery.
9. The last branch of the maxillary artery to be dissected at this time is the **buccal artery**, which passes anteriorly onto the buccinator muscle to supply the cheek. *Note that the buccal artery may be quite small and is often difficult to dissect.*

## Pterygoid Muscles

ATLAS 7.50A, 7.53C; VIDEO 7.8.5

1. Refer to FIGURE 7.33.
2. Identify the **lateral pterygoid muscle** coursing horizontally through the infratemporal fossa.
3. Use blunt dissection to clean the surface of the lateral pterygoid muscle and identify the plane of separation between its superior and inferior heads. *Note that the lateral pterygoid is innervated by branches of CN $V_3$ along with the other muscles of mastication; however, it is unique in that it acts to open the jaw.*
4. Review the attachments and actions of the lateral pterygoid muscle (see **TABLE 7.5**).
5. Inferior to the lateral pterygoid muscle, identify the **medial pterygoid muscle**. Reflect the masseter back and forth to observe that the medial pterygoid has a similar fiber orientation and thus would act in a similar fashion to close the jaw.
6. Observe that the lingual nerve and inferior alveolar nerve pass between the inferior border of the

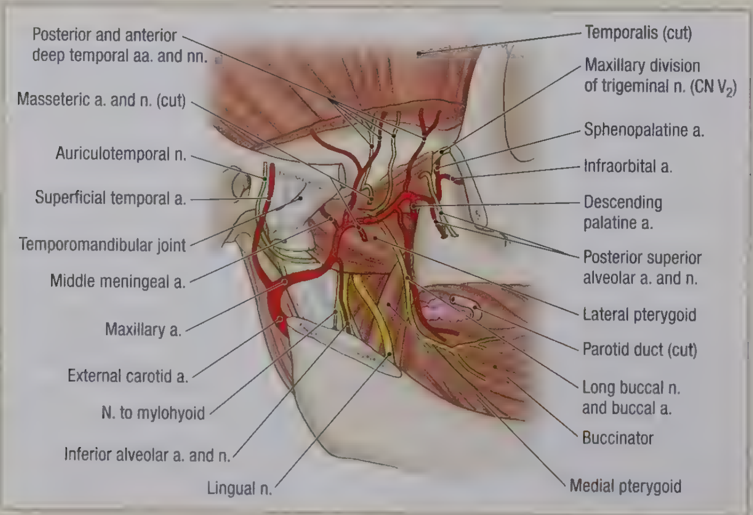

Posterior and anterior deep temporal aa. and nn.
Masseteric a. and n. (cut)
Auriculotemporal n.
Superficial temporal a.
Temporomandibular joint
Middle meningeal a.
Maxillary a.
External carotid a.
N. to mylohyoid
Inferior alveolar a. and n.
Lingual n.
Temporalis (cut)
Maxillary division of trigeminal n. (CN V2)
Sphenopalatine a.
Infraorbital a.
Descending palatine a.
Posterior superior alveolar a. and n.
Lateral pterygoid
Parotid duct (cut)
Long buccal n. and buccal a.
Buccinator
Medial pterygoid

FIGURE 7.33 ● Superficial dissection of the infratemporal fossa. Lateral view.

lateral pterygoid muscle and the medial pterygoid muscle.

7. Clean the surface of the medial pterygoid muscle using the lingual nerve as a guide to assist in identification of the plane of separation between the two pterygoid muscles.
8. Review the attachments and actions of the medial pterygoid muscle (see TABLE 7.5).
9. Define the inferior border of the lateral pterygoid muscle by inserting a probe between it and the medial pterygoid muscle.
10. Use scissors to cut the lateral pterygoid muscle close to its posterior attachments to the neck of the mandible and the articular disc.
11. Remove the muscle in a piecemeal fashion to preserve superficially positioned nerves and vessels.

***Dissection Note:*** If the maxillary artery coursed deep to the lateral pterygoid, then it may be possible to simply reflect the lateral pterygoid anteriorly and avoid removing it completely from the dissection field.

12. Use blunt dissection to follow the **inferior alveolar nerve** and the **lingual nerve** superiorly toward the foramen ovale in the roof of the infratemporal fossa.
13. Refer to FIGURE 7.34.
14. Return to the proximal end of the maxillary artery and identify the now exposed middle meningeal artery arising medial to the neck of the mandible and courses superiorly deep to the lateral pterygoid muscle.
15. Observe that just below the base of the skull, the middle meningeal artery is encircled by the **auriculotemporal nerve** prior to passing through the foramen spinosum to enter the middle cranial fossa and supply the dura mater.
16. Use blunt dissection to carefully separate the loop of nervous tissue from around the middle meningeal artery, noting that the auriculotemporal nerve is the only posteriorly oriented branch of the **mandibular division of trigeminal nerve** (CN $V_3$).
17. Identify the **chorda tympani**, a thin nerve that joins the posterior side of the **lingual nerve** high in the infratemporal fossa.
18. Follow the maxillary artery toward the **pterygopalatine fossa.**
19. Observe that prior to entering the pterygopalatine fossa, the maxillary artery divides into four branches: posterior superior alveolar artery, infraorbital artery, descending palatine artery, and sphenopalatine artery. At this time, identify only the **posterior superior alveolar artery,** which enters the infratemporal surface of the maxilla. The other branches will be dissected later.

## Temporomandibular Joint

ATLAS 7.50A, 7.55, 7.56; VIDEO 7.8.6

1. Refer to FIGURE 7.34.
2. Identify the capsule of the TMJ and use a pair of forceps to observe that the joint capsule is loose to allow for increased mobility.
3. Observe that the lateral surface of the joint capsule is reinforced by the **lateral ligament.**
4. Preserve the superficial temporal vessels and auriculotemporal nerve by gently pulling them away from the TMJ.
5. Use a scalpel to trim away the lateral side of the joint capsule and the lateral ligament.

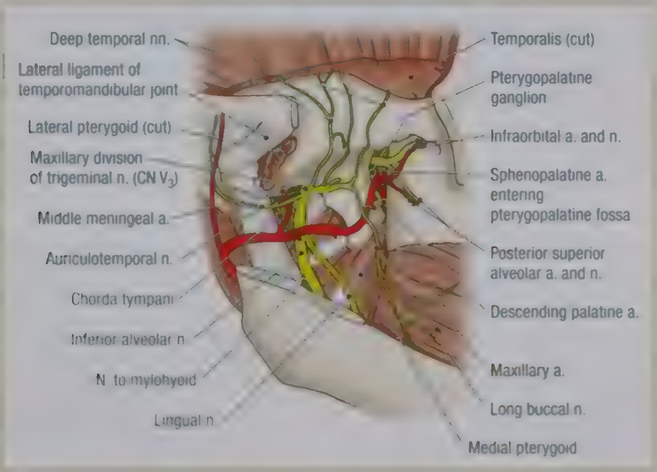

Deep temporal nn.
Lateral ligament of temporomandibular joint
Lateral pterygoid (cut)
Maxillary division of trigeminal n. (CN $V_3$)
Middle meningeal a.
Auriculotemporal n.
Chorda tympani
Inferior alveolar n.
N. to mylohyoid
Lingual n.
Temporalis (cut)
Pterygopalatine ganglion
Infraorbital a. and n.
Sphenopalatine a. entering pterygopalatine fossa
Posterior superior alveolar a. and n.
Descending palatine a.
Maxillary a.
Long buccal n.
Medial pterygoid

FIGURE 7.34 ● Deep dissection of the infratemporal fossa. Lateral view.

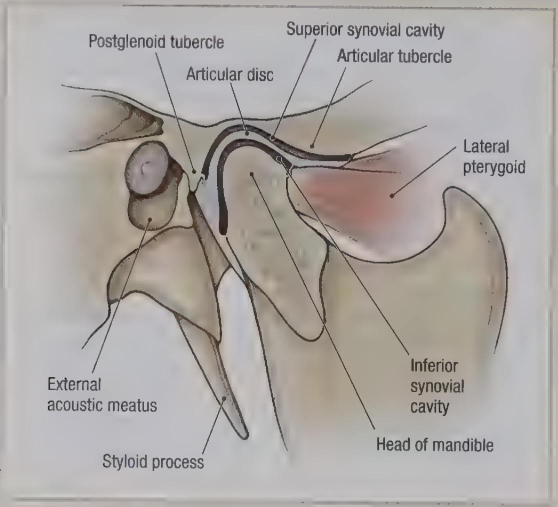


FIGURE 7.35 ● Sagittal section of the right temporomandibular joint. Right lateral view.

6. Refer to FIGURE 7.35.
7. Within the joint, identify the **articular disc** and note its location between the mandibular fossa of the temporal bone and the head of the mandible. *Note that the tendon of the lateral pterygoid muscle is attached to both the neck of the mandible and the articular disc.*
8. Examine the articular disc and note that it is thin near its center and thicker near its edges.
9. Insert a probe both superior and inferior to the disc and identify the **superior** and **inferior synovial cavities.**
10. Move the small remaining portion of the head of the mandible and observe the two types of movements that occur in the TMJ. Verify that in the superior synovial cavity, gliding movements occur between the articular disc and the mandibular fossa (protrusion and retrusion) and that in the inferior synovial cavity, hinge movements occur between the head of the mandible and the articular disc.

## Dissection Follow-up

1. Review the attachments and actions of the muscles of mastication in **TABLE 7.5.**
2. Review the path of the mandibular division of the trigeminal nerve through the foramen ovale into the infratemporal fossa and review its sensory and motor branches.
3. Follow the external carotid artery from its origin near the hyoid bone to the infratemporal fossa reviewing the location of its two terminal branches.
4. Follow the branches of the maxillary artery that were identified in dissection to their regions of supply.
5. Review the relationship of the middle meningeal artery to the auriculotemporal nerve.
6. Replace the reflected muscles of mastication and tissues of the infratemporal region in their correct anatomical positions.

**TABLE 7.5 Muscles of Mastication**

| *Muscle* | *Superior Attachments* | *Inferior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Masseter | Inferior border and medial surface of zygomatic arch | Lateral surface of ramus and angle of mandible | Elevates and protrudes mandible | CN $V_3$ via masseteric n. |
| Temporalis | Floor of temporal fossa and deep surface of temporal fascia | Tip and medial surface of coronoid process and anterior border of ramus of mandible | Elevates and retrudes mandible | CN $V_3$ via deep temporal nn. |
| Medial pterygoid | Medial surface of lateral pterygoid plate (deep head)<br>Tuberosity of maxilla (superficial head) | Medial surface of ramus of mandible | Elevates and protrudes mandible (bilateral)<br>Side to side movement of mandible (unilateral) | CN $V_3$ via medial pterygoid n. |
| Lateral pterygoid | Infratemporal surface and infratemporal crest of greater wing of sphenoid (superior head)<br>Lateral surface of lateral pterygoid plate (inferior head) | Neck of mandible, articular disc, and capsule of TMJ | Depresses and protrudes mandible (bilateral)<br>Side-to-side movement of mandible (unilateral) | CN $V_3$ via lateral pterygoid n. |

Abbreviations: CN, cranial nerve; n., nerve; nn., nerves; TMJ, temporomandibular joint.

## INTERIOR OF THE SKULL

### Dissection Overview

Many schools remove the brain before the cadaver is placed on the dissection table. If the brain has been removed in your cadaver, skip ahead to the section entitled "Cranial Meninges." If you must remove the brain yourself, proceed with the following instructions.

The bones of the calvaria provide a protective covering for the cerebral hemispheres and consist of three layers. The outer lamina and inner lamina are composed of compact bone, whereas the middle layer between the outer and inner laminae, the diploë, is composed of spongy bone as shown in FIGURE 7.36.

Within the cranial cavity, the brain is covered with three membranes called meninges, which serve to further protect and support it. Additionally, the meninges serve as the framework for cerebral arteries and veins and form the spaces containing venous blood draining from the brain (dural venous sinuses) and the space containing the cerebrospinal fluid (CSF) (subarachnoid space). The dura mater is the outer layer of tough membrane, the arachnoid mater is the "cobweb"-like intermediate membrane, and the pia mater is a delicate membrane closely applied to the surface of the brain.

The order of dissection will be as follows: The remaining layers of scalp and the temporalis muscle will be reflected inferiorly. The calvaria will be cut with a saw and removed. The dura mater will be examined and then opened to reveal the arachnoid mater and pia mater.

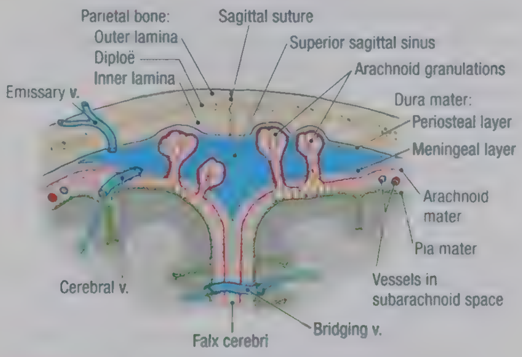

Parietal bone:
Outer lamina
Diploë
Inner lamina
Sagittal suture
Superior sagittal sinus
Arachnoid granulations
Emissary v.
Dura mater:
Periosteal layer
Meningeal layer
Arachnoid mater
Pia mater
Vessels in subarachnoid space
Cerebral v.
Bridging v.
Falx cerebri

FIGURE 7.36 ■ Coronal section through the superior sagittal sinus and meninges. Anterior view.

### Dissection Instructions

#### Removal of the Calvaria

VIDEO 7.9.1

1. Refer to FIGURE 7.37.
2. With the cadaver in the supine position, reflect the **frontalis** and **occipitalis** (frontal and occipital bellies of the occipitofrontalis) and any remaining layers of the scalp inferiorly.
3. Use a scalpel to detach the **temporalis muscle** from the calvaria by cutting it from its attachments at the **superior** and **inferior temporal lines** and reflect the muscle inferiorly.
4. Identify the **pericranium (periosteum)** the last layer of the scalp, which covers the surface of the calvaria directly.
5. Use a scalpel or chisel to scrape the bones of the calvaria clean of pericranium and any remaining muscle fibers.
6. Place a rubber band around the circumference of the skull. Anteriorly, the rubber band should be about 2 cm superior to the supraorbital margin. Posteriorly, the rubber band should cross the external occipital protuberance.
7. Trace the circumference of the calvaria with a pencil or magic marker following the rubber band. Once the complete circumference of the skull has been traced, remove the rubber band.
8. Draw a vertical line from above the ear on one side of the head up and over the vertex of the skull to a similar location on the opposite side. The vertical

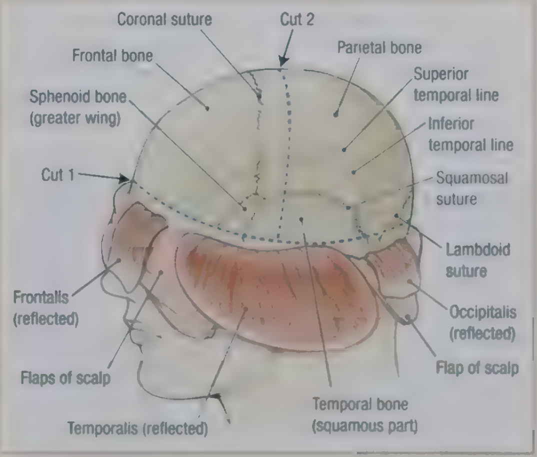

Coronal suture
Cut 2
Frontal bone
Parietal bone
Sphenoid bone (greater wing)
Superior temporal line
Inferior temporal line
Cut 1
Squamosal suture
Lambdoid suture
Frontalis (reflected)
Occipitalis (reflected)
Flaps of scalp
Flap of scalp
Temporal bone (squamous part)
Temporalis (reflected)

FIGURE 7.37 ■ Reflection of the temporalis and occipitofrontalis muscles and cuts for calvaria removal. Left lateral view.

line should effectively divide the skull into anterior and posterior halves.

9. Use a saw to cut along the marked lines around the circumference of the skull (**Cut 1**) passing only through the outer lamina of the calvaria but not completely through the bone. If you saw through the inner lamina, you may damage the underlying dura mater or the brain.
10. To facilitate the cuts through the calvaria, turn the body alternately from supine to prone and then back to supine while sawing.

***Dissection Note:*** Be particularly careful when cutting the squamous part of the temporal bone, which is very thin. Moist red bone on the saw blade indicates that the saw is within the diploë and at an appropriate depth.

11. Use a saw to cut along the vertical line arching over the superior aspect of the skull (**Cut 2**) connecting to the horizontal line around its circumference on each side.
12. After making a complete circumferential cut, break the inner lamina of the calvaria by repeatedly inserting a chisel into the saw cut and striking the chisel gently with a mallet. Once the skull has been completely cut through, you should see a small amount of movement between the portions of cut skull.
13. Use a "T-tool" if available, or the edge of the chisel, to create a small amount of movement and increase the space between the cut pieces of bone and the circumference of the skull, by inserting and twisting the instrument. While doing so, you will hear a distinct tearing sound as the dura mater is separated from the overlying bone.
14. Beginning with the anterior portion of sectioned bone, elevate the cut portion of bone by prying it from the dura mater with a chisel. Continue to elevate the anterior half of the calvaria and remove the portion of bone by tilting it toward the forehead. *Note that violent pulling may result in tearing the dura mater and damaging the brain.*
15. Using the cut edge of bone as a guide, insert the handle of a forceps under the posterior potion of bone to push away the periosteal layer of dura mater from the deep surface of the bone.
16. Repeat the process to remove the remaining posterior half of the calvaria using a chisel as leverage against the bones. Again, do not use more force than is necessary to avoid unnecessary risk to the underlying brain.
17. On the inner surface of the removed calvaria, identify the grooves formed by the middle meningeal artery. Compare the grooves with the visible vessels on the surface of the dura mater and recall that the middle meningeal artery arose from the maxillary artery in the infratemporal fossa.

## Cranial Meninges

ATLAS 7.22, 7.23, 7.24; VIDEO 7.9.2

1. Refer to FIGURE 7.38.
2. Identify the **dura mater**, which consists of two layers, an external **periosteal layer** and internal **meningeal layer**. *Note that the two dural layers are indistinguishable except where they separate to enclose the dural venous sinuses and form the falx cerebri and falx cerebelli.*
3. Identify the **superior sagittal sinus**, a dural venous sinus coursing along the superior extent of the cranial cavity in the midline.
4. Use scissors to make a longitudinal incision in the superior sagittal sinus through the periosteal layer of dura mater near the vertex for a short distance (**Cut 1**). Use forceps to gently spread open the sinus and verify that its inner surface is smooth because it is lined by endothelium.
5. Extend the incision through the periosteal layer of dura to the frontal bone anteriorly (**Cut 2**) and to the cut edge of the occipital bone posteriorly (**Cut 3**). Observe that the caliber of the superior sagittal sinus increases from anterior to posterior following the direction of venous blood flow.

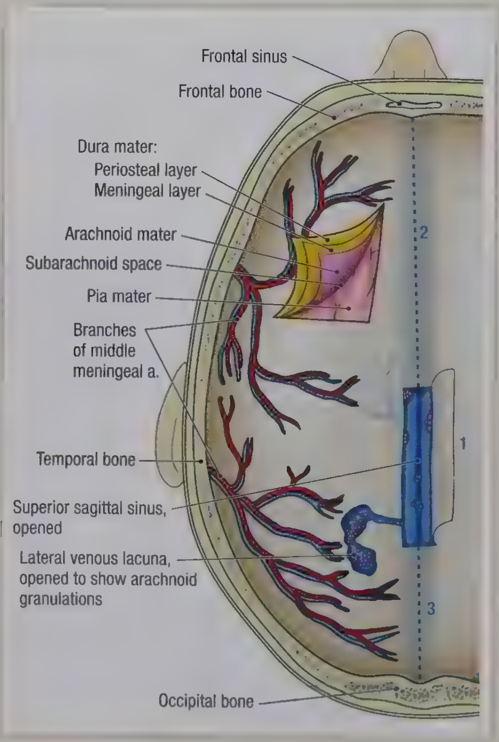


FIGURE 7.38 ■ The cranial meninges and opening of the superior sagittal sinus. Superior view.

6. Gently insert a probe into the lateral expansions along the wall of the sinus and identify the **lateral venous lacunae**. Within a lateral venous lacunae, identify the **arachnoid granulations** responsible for the return of CSF to the venous system.
7. Examine the surface of the dura mater that covers the cerebral hemispheres and observe the branches of the **middle meningeal artery**. The middle meningeal artery supplies the dura mater and adjacent calvaria. *Note that the anterior branch of the middle meningeal artery crosses the inner surface of the pterion, where it may tunnel through the bone.*
8. Examine the inner surface of the removed calvaria and identify the **groove for the superior sagittal sinus** as well as the **grooves for the branches of the middle meningeal artery**.

CLINICAL CORRELATION

**Epidural Hemorrhage**

ATLAS 7.21, 7.22B

Fractures through the pterion, the weak point of junction of the parietal, frontal, and temporal bones, may result in tearing of the underlying middle meningeal artery. Rupture of the middle meningeal artery causes an epidural hemorrhage (extradural hematoma), resulting in blood accumulation between the skull and the periosteal layer of dura mater. Bleeding into the epidural space results in a life-threatening increased pressure on the underlying cerebral cortex within hours if left untreated.

9. Refer to FIGURE 7.39.
10. Use scissors to cut through the dura mater along the circumference of the cut edge of the calvaria (**Cuts 4** and **5**). Bilaterally, stop the cut posteriorly at a point about 3.5 cm lateral to the midline. The objective is to permit the dura mater to be pulled free from the surface of the brain but to leave it attached posteriorly in the area of the superior sagittal sinus.
11. Use blunt dissection to gently retract the anterior pole of the dura mater and insert scissors between the cerebral hemispheres to cut the **falx cerebri (cerebral falx)** where it attaches to the crista galli. The falx cerebri is an extension of the meningeal layer of dura mater, which descends between the cerebral hemispheres along the midline to physically separate the right and left cerebral hemispheres.
12. Grasp the anterior pole of the dura mater and gently pull it posteriorly, gradually working the falx cerebri free from between the cerebral hemispheres as you progress.

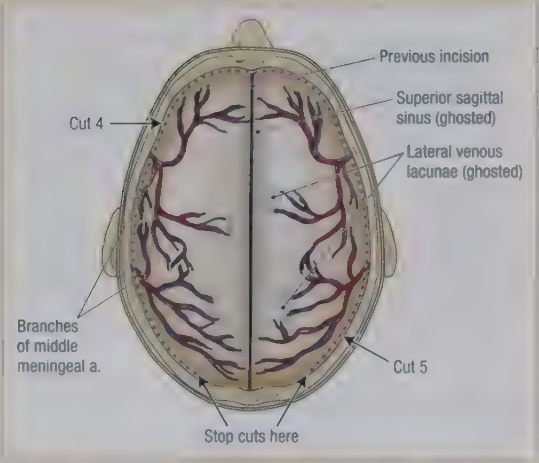

Previous incision
Superior sagittal sinus (ghosted)
Cut 4
Lateral venous lacunae (ghosted)
Branches of middle meningeal a.
Cut 5
Stop cuts here

FIGURE 7.39 ■ Circumferential cut to reflect the dura mater. Superior view.

13. Observe **bridging veins** that pass from the surface of the brain from the superior cerebral veins into the superior sagittal sinus along its lateral sides.
14. Cut the bridging veins as you pull the dura mater posteriorly to permit the falx cerebri to be completely retracted from between the cerebral hemispheres until the dura mater is attached to the skull only near its posterior pole. *Note that the reflected portion of dura mater will be removed along with the brain dissection.*
15. Deep to the location of the now reflected dura mater, identify the **arachnoid mater** covering the surface of the brain, named in reference to the spiderweb-like connective tissue strands in the subarachnoid space.

CLINICAL CORRELATION

**Subdural and Subarachnoid Hemorrhages**

ATLAS 7.22C, 7.22D

Head trauma may tear the cerebral veins at the point where they enter the superior sagittal sinus, or the bridging veins passing through the falx cerebri. The venous blood from the tear accumulates in the potential space between the dura mater and the arachnoid mater creating a "subdural space" in a condition called a subdural hematoma. By comparison, a rupture of a cerebral artery from a burst aneurism will bleed into the subarachnoid space, a true space occupied by CSF, in a condition called a subarachnoid hemorrhage.

A subdural hematoma of venous blood may spread further than an epidural bleed because it is not limited by the dural adhesions to the sutures. Despite a slower onset subdural hemorrhages may still lead to loss of consciousness and be life threatening if left untreated.

16. Observe that the arachnoid mater loosely covers the brain and spans across the fissures and sulci. In the living person, the arachnoid mater is closely applied to the internal meningeal layer of the dura mater with no space between due to the pressure of CSF in the subarachnoid space.
17. Observe the **cerebral veins** that are visible through the arachnoid mater. The cerebral veins empty into the superior sagittal sinus via bridging veins, which were cut during the reflection of the dura mater.
18. Use scissors to make a small cut (2.5 cm) through the arachnoid mater over the lateral surface of the brain. Use a probe to elevate the arachnoid mater and observe the **subarachnoid space**. In the living person, the subarachnoid space is a real space that contains CSF. In the cadaver, the arachnoid mater appears "deflated" because the CSF is no longer present.
19. Through the opening in the arachnoid mater, observe the **pia mater** on the surface of the brain. *Note that the pia mater faithfully follows the contours of the brain, passing into all sulci and fissures and cannot be removed from the surface of the brain.*

## Dissection Follow-up

1. Review the bones that form the calvaria.
2. Review the external features of the cranial dura mater and note that the external periosteal layer is attached to the skull.
3. Review the features of the spinal dura mater and compare it to the cranial dura mater.
4. Compare and contrast the features of an epidural, subdural, and subarachnoid hematomas.
5. Return the reflected portion of dura mater back to its anatomical position.
6. Wrap the head with a moist towel or wrapping soaked with embalming fluid or wetting solution to prevent desiccation of the exposed meninges and brain.

# BRAIN REMOVAL, DURAL INFOLDINGS, AND DURAL VENOUS SINUSES

## Dissection Overview

The internal meningeal layer of the dura mater forms inwardly projecting folds (dural infoldings) that serve as incomplete partitions of the cranial cavity. Three of these folds (falx cerebri, tentorium cerebelli, and falx cerebelli) extend inward between parts of the brain. Recall that the periosteal and meningeal layers of the dura mater separate from each other in several locations to form dural venous sinuses. The dural venous sinuses collect venous drainage from the brain and conduct it out of the cranial cavity.

The order of dissection will be as follows: Bony features of the cranial cavity will be studied on a skull. The dural infoldings will be cut to facilitate brain removal. The brain will be removed intact, along with the arachnoid mater and pia mater. The dura mater will be repositioned to recreate its three-dimensional morphology during life. The infoldings of the dura mater and the associated dural venous sinuses will be identified.

### Skeletal Anatomy

#### *Cranial Fossae*

ATLAS 7.6

On a skull with the calvaria removed, review the following skeletal features.

1. Refer to FIGURE 7.40.
2. Within the cranial cavity, identify the three **cranial fossae**.
3. Anteriorly, identify the **anterior cranial fossa** and observe that it is predominantly formed by the right and left **orbital plates of the frontal bone**.
4. Between the orbital plates, identify the **crista galli**, the small ridge-like process serving as the anterior attachment of the falx cerebri, of the ethmoid bone. Observe that to either side of the crista galli is the **cribriform plate**, a small depression with multiple apertures superior to the nasal cavity.
5. At the border between the anterior and middle cranial fossae, identify the ridge formed by the **lesser wing of the sphenoid**. Observe that the ridge ends medially as the rounded **anterior clinoid process**.

6. Identify the middle cranial fossa and observe that it is formed by the **greater wing of the sphenoid** and the **petrous part of the temporal bone**.
7. In the midline of the skull between the right and left middle cranial fossae, identify the saddle-shaped depression of the **hypophyseal fossa (sella turcica)**. In the living person, the sella turcica supports the pituitary gland.
8. On the posterior aspect of the **sella turcica**, identify the **posterior clinoid processes**, which demarcate the posterior aspect of the sphenoid bone.
9. Lateral and posterior to the sella turcica, identify the **petrous ridge** of the temporal bone separating the **middle** and **posterior cranial fossae**. *Note that the petrous ridge serves as the anterior attachment of the tentorium cerebelli.*
10. Identify the **internal acoustic meatus** on the vertical part of the petrous portion of the temporal bone within the posterior cranial fossa. *Note that the internal acoustic meatus is the medial opening leading to the inner and middle ear.*
11. Identify the **jugular foramen**, a large somewhat bean-shaped hole inferior to the internal acoustic meatus between the temporal and occipital bones.
12. Observe that the **groove for the sigmoid sinus** follows the inferior border of the petrous portion of the temporal bone as it courses medially and terminates at the jugular foramen. *Note that the sigmoid sinus is a dural venous sinus that drains cerebral blood to the internal jugular vein.*
13. Trace the groove for the sigmoid sinus laterally and observe that it is continuous with the anterior aspect of the **groove for the transverse sinus**. *Note that the transverse sinus is a dural venous sinus that courses in the lateral edge of the tentorium cerebelli.*
14. Within the **posterior cranial fossa**, identify the large **foramen magnum** positioned in the midline. *Note that the foramen magnum allows passage of the spinal cord into the vertebral canal from the inferior extent of the brainstem, as well as the vertebral arteries, which supply the posterior aspect of the brain.*
15. Within the wall of the foramen magnum, identify the **hypoglossal canal**.

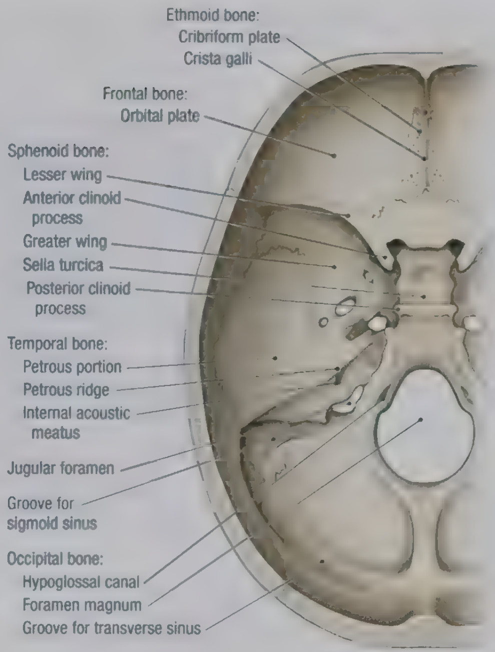


FIGURE 7.40 ■ Floor of the cranial cavity. Superior view.

## Dissection Instructions

### Removal of the Brain

ATLAS 7.26; VIDEO 7.10.1

***Dissection Note:*** If the brain has been removed from your cadaver, skip ahead to the section entitled **Dural Infoldings**. The structures cut to remove the brain will be reviewed after the brain has been removed.

1. Refer to FIGURE 7.41.
2. Retract the dura mater overlying the surface of the right and left cerebral hemispheres, along with the anterior aspect of the falx cerebri. If the falx proves difficult to elevate, ensure that the entire extension of the meningeal layer of dura was detached from the crista galli (**Cut 1**).
3. Gently elevate the frontal lobes of the brain.
4. Use a probe to lift the olfactory bulb from the cribriform plate on each side of the crista galli.
5. As you elevate the anterior aspect of the cerebral hemispheres, carefully use a scalpel to cut the following structures bilaterally: optic nerve, internal carotid artery, and oculomotor nerve. Cut the stalk of the pituitary gland in the midline.
6. On the right side, gently lift the temporal lobe (lateral part of brain) and identify the **tentorium cerebelli (cerebellar tentorium)**.
7. Use a scalpel to cut the cerebellar tentorium as close to the superior border of the petrous part of the temporal bone as possible (**Cut 2**). The cut should begin anteriorly near the posterior clinoid process and extend posterolaterally to the end of the superior border of the petrous part of the temporal bone, near the groove for the sigmoid sinus.

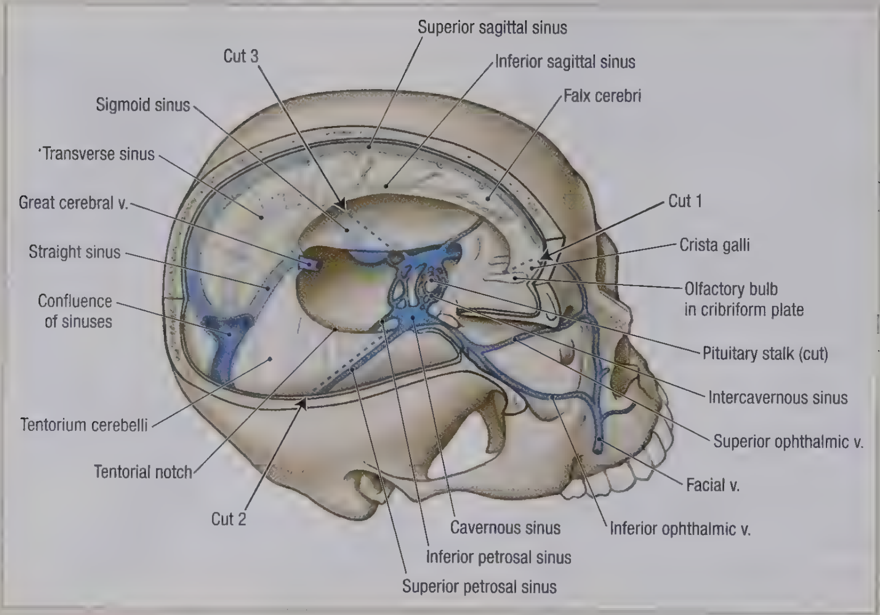

Superior sagittal sinus
Cut 3
Inferior sagittal sinus
Falx cerebri
Sigmoid sinus
Transverse sinus
Great cerebral v.
Straight sinus
Confluence of sinuses
Cut 1
Crista galli
Olfactory bulb in cribriform plate
Pituitary stalk (cut)
Intercavernous sinus
Superior ophthalmic v.
Facial v.
Tentorium cerebelli
Tentorial notch
Cut 2
Cavernous sinus
Inferior ophthalmic v.
Inferior petrosal sinus
Superior petrosal sinus

FIGURE 7.41 ■ Dural infoldings and dural venous sinuses. Right superolateral view.

8. Repeat the cut of the tentorium cerebelli on the left side of the cadaver (**Cut 3**).
9. Inferior to the cut edge of the tentorium, ensure that the trochlear nerve, trigeminal nerve, and abducens nerve were cut bilaterally. With the cerebellar tentorium cut, the brain may be gently moved to gain access to structures that lie inferior to the tentorium.
10. Elevate the cerebrum and brainstem slightly and cut the following structures bilaterally: facial and vestibulocochlear nerves near the internal acoustic meatus; glossopharyngeal, vagus, and accessory nerves near the jugular foramen; and the hypoglossal nerves near the hypoglossal canal within the walls of foramen magnum.
11. Use a scalpel to sever the two vertebral arteries where they enter the skull through the foramen magnum and the cervical spinal cord as low in the foramen magnum (or cervical vertebral canal) as you can reach.
12. Support the cerebral hemispheres from behind with the palm of one hand. Insert the other hand (palm facing superiorly) between the frontal lobes and the skull with your middle finger extending down the ventral surface of the brainstem. Insert the tip of your middle finger into the cut that was made across the cervical spinal cord to support the brainstem and cerebellum.
13. Using upward pressure on the cut end of the cervical spinal cord, roll the brain, brainstem, and cerebellum posteriorly and out of the cranial cavity in one piece. If done properly, the meningeal infoldings of the dura mater will be left attached to the skull.
14. Return the dura mater to its correct anatomical position.
15. The brain should be stored in a bath of preservative fluid.

## Dural Infoldings

ATLAS 7.24A, 7.25B; VIDEO 7.10.2

1. Refer to FIGURE 7.41.
2. Identify the **falx cerebri (cerebral falx)** between the cerebral hemispheres.
3. Observe that the cerebral falx is attached to the crista galli at its anterior end, to the calvaria on both sides of the groove for the superior sagittal sinus, and to the tentorium cerebelli posteriorly.
4. Identify the **tentorium cerebelli (cerebellar tentorium)**.
5. Observe that the tentorium cerebelli is attached to the clinoid processes of the sphenoid bone, the superior border of the petrous portion of the temporal bone, and the occipital bone on both sides of the groove for the transverse sinus.
6. Identify the **tentorial notch (tentorial incisure)**, the opening in the cerebellar tentorium between the right and left sides that allows passage of the brainstem. The cerebellar tentorium is between the cerebral hemispheres and the cerebellum.

7. Identify the **falx cerebelli (cerebellar falx)**, a low ridge of dura mater located inferior to the tentorium cerebelli in the midline.
8. Observe that the falx cerebelli is attached to the inner surface of the occipital bone and that it is located between the cerebellar hemispheres.

### Dural Venous Sinuses

ATLAS 7.25; VIDEO 7.10.3

1. Refer to FIGURE 7.41.
2. Review the position of the **superior sagittal sinus** and observe that the superior sagittal sinus begins near the crista galli anteriorly and ends by draining into the **confluence of sinuses**.
3. Identify the **inferior sagittal sinus** in the inferior margin of the falx cerebri, which ends near the tentorium cerebelli by draining into the anterior end of the **straight sinus**. *Note that the inferior sagittal sinus is much smaller in diameter than the superior sagittal sinus.*
4. Identify the location of the straight sinus in the line of junction of the falx cerebri and the tentorium cerebelli. At its anterior end, the straight sinus receives the inferior sagittal sinus and the **great cerebral vein** and drains into the confluence of sinuses. *Note that the great cerebral vein was torn when the brain was removed.*
5. Identify the **transverse sinuses** (right and left). Each transverse sinus carries venous blood from the confluence of sinuses to the sigmoid sinus.
6. On one side, use a scalpel to open the lumen of the transverse sinus and note that it is lined with smooth endothelium.
7. Identify the right and left **sigmoid sinuses**. Each sigmoid sinus begins at the lateral end of the transverse sinus and ends at the jugular foramen.
8. On one side, use a scalpel to open the lumen of the sigmoid sinus and trace it medially to the jugular foramen. *Note that the internal jugular vein forms at the external surface of the jugular foramen.*
9. On the floor of the cranial cavity, observe that the dura mater covers all of the bones and contains openings through which the cranial nerves pass.
10. Observe that additional small dural venous sinuses are located between the layers of the dura mater in the floor of the cranial cavity. Identify the location of the **sphenoparietal sinus, cavernous sinus, superior petrosal sinus, inferior petrosal sinus,** and **basilar plexus**. *Do not make an effort to dissect the cavernous sinus at this point of the dissection as this will be done later.*

## Dissection Follow-up

1. Review the bones that form the floor of the cranial cavity.
2. Review the major skeletal features in each of the three cranial fossae.
3. Review the location of the dural infoldings and discuss the portions of the brain separated by each.
4. Naming all venous structures encountered along the way, trace the route of a drop of blood from a superior cerebral vein to the internal jugular vein, from the sphenoparietal sinus to the sigmoid sinus, and from the great cerebral vein to the internal jugular vein.
5. Return the reflected dural infoldings and cut dura mater back to anatomical position.
6. Wrap the head with a moist towel or wrapping soaked with embalming fluid or wetting solution to prevent desiccation of the exposed meninges and brain.

# GROSS ANATOMY OF THE BRAIN

## Dissection Overview

The brain consists of the cerebrum (cerebral hemispheres and diencephalon), the brainstem (midbrain, pons, and medulla oblongata), and the cerebellum. The study of brain anatomy and its function is highly specialized and usually reserved for a neuroscience course. Because the full extent of brain function is not meant to be covered in most dissection-based courses, the description provided here is intended to relate the major features of the external surface of the brain and to the parts of the skull that will be studied in subsequent dissections. An additional goal of this study is to establish a mental picture of the continuity of the arteries and nerves of the brain with those same structures that are left behind in the cranial fossae after brain removal.

The order of dissection will be as follows: The gross anatomy of the brain will be studied including the major lobes, fissures, sulci, and gyri. The blood supply of the brain will be studied including a detailed look at the cerebral arterial circle (circle of Willis). The twelve cranial nerves will be studied from an inferior perspective of the brain.

# Dissection Instructions

## Brain

ATLAS 7.97, 7.99A; VIDEO 7.11.1

***Dissection Note:*** Review the following neural features on a brain that has been stored in a bath of preservative fluid.

1. Refer to FIGURE 7.42.
2. Observe that the human brain is subdivided according to large points of separation created by two major **fissures**. Identify the **longitudinal fissure**, which separates the cerebrum into **right** and **left cerebral hemispheres**, and the **transverse fissure**, which separates the cerebrum from the **cerebellum**, with the **brainstem** acting as the bridge between the two.
3. Examine the surface of the brain and observe that it is composed of **gyri** (raised regions) and **sulci** (grooves).
4. On the **lateral surface of the brain**, identify the **central sulcus** between the **precentral gyrus** (primary motor cortex) of the **frontal lobe** and the **postcentral gyrus** (primary sensory cortex) of the **parietal lobe**.

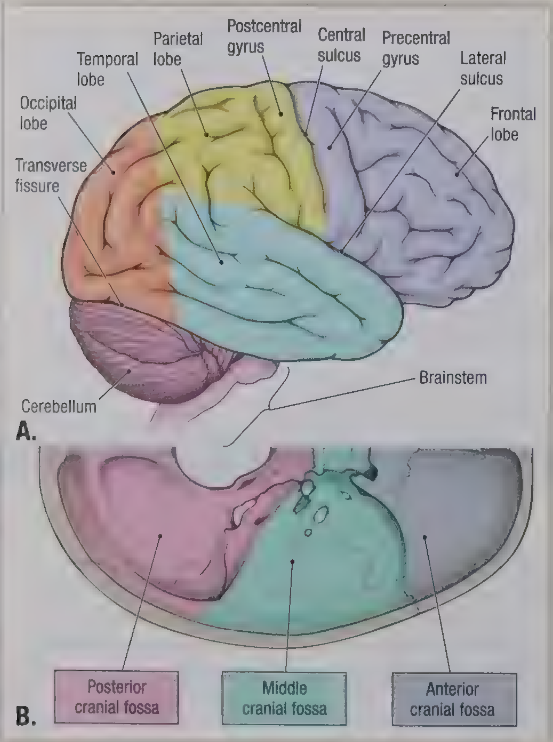


FIGURE 7.42 ● **A.** Surface anatomy of the brain. Right lateral view. **B.** Cranial fossae. Superior view.

5. Identify the **temporal lobe** of the brain laterally and observe that it is separated from the frontal and parietal lobes by the **lateral sulcus**.
6. On the posterior aspect of the brain, identify the **occipital lobe** superior to the transverse fissure.
7. Refer to a skull and identify the **three cranial fossae**: **anterior**, **middle**, and **posterior**.
8. Use the cadaver and the brain to verify that the **frontal lobe** is located in the **anterior cranial fossa**, that the **temporal lobe** is located in the **middle cranial fossa**, and that the **cerebellum** is located in the **posterior cranial fossa**.
9. Observe that the **occipital lobe** is located superior to the tentorium cerebelli and therefore superior to the groove of the transverse sinus.
10. Observe that the **brainstem** becomes continuous with the cervical spinal cord at the **foramen magnum**.

## Blood Supply to the Brain

ATLAS 7.29, 7.32, 7.33; VIDEO 7.11.2

1. Refer to FIGURE 7.43.
2. Examine the surface of the brain and observe that it is covered by arachnoid mater.
3. Use a probe to peel back the arachnoid mater and expose the arteries on the inferior surface of the brain.
4. Identify the four arteries that supply blood to the brain: the two vertebral arteries posteriorly and the two internal carotid arteries anteriorly.
5. Observe that each **vertebral artery** gives rise to one **posterior inferior cerebellar artery (PICA)** prior to combining to form the unpaired **basilar artery** in the approximate midline of the brainstem.
6. Arising from the basilar artery, identify the **anterior inferior cerebellar artery (AICA)**, the **superior cerebellar artery**, and several **pontine branches** arising bilaterally.
7. Follow the basilar artery superiorly and observe that it terminates by branching into the paired **posterior cerebral arteries**.
8. Observe that each posterior cerebral artery gives a **posterior communicating artery**, which anastomoses with the **internal carotid artery**.
9. Within the cranial cavity, identify the cut edge of the internal carotid artery.
10. Observe that the first branch of the internal carotid artery, the **ophthalmic artery**, arises medial to the anterior clinoid process and passes through the optic foramen with the **optic nerve**.
11. On the inferior aspect of the brain, observe that each internal carotid artery terminates by dividing into a **middle cerebral artery** and an **anterior cerebral artery**.

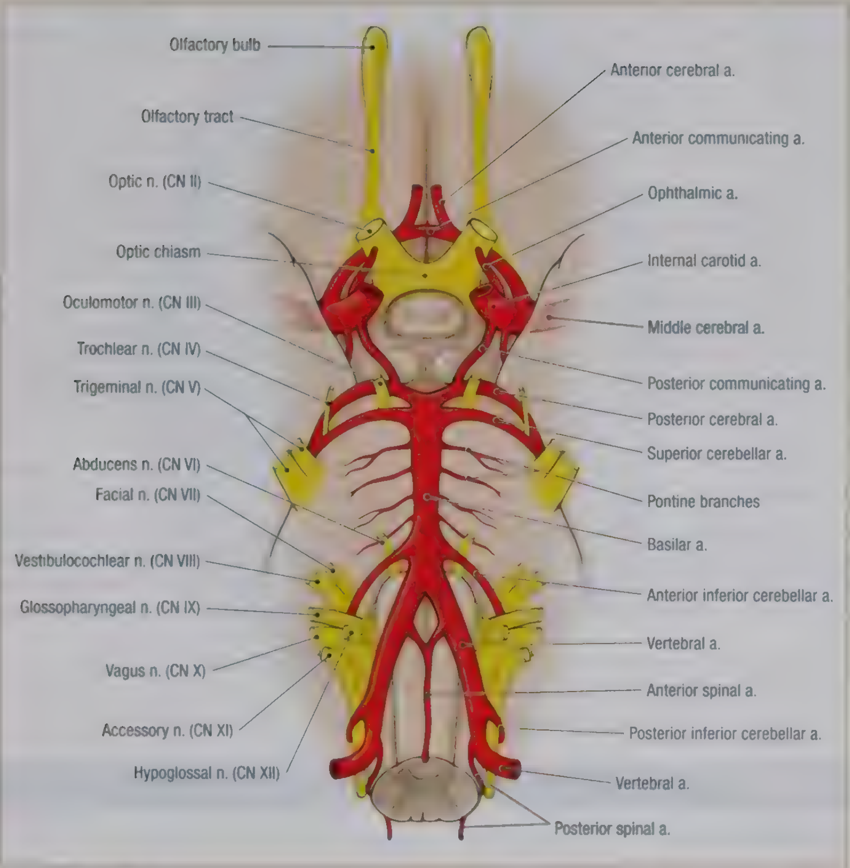

Olfactory bulb
Olfactory tract
Optic n. (CN II)
Optic chiasm
Oculomotor n. (CN III)
Trochlear n. (CN IV)
Trigeminal n. (CN V)
Abducens n. (CN VI)
Facial n. (CN VII)
Vestibulocochlear n. (CN VIII)
Glossopharyngeal n. (CN IX)
Vagus n. (CN X)
Accessory n. (CN XI)
Hypoglossal n. (CN XII)
Anterior cerebral a.
Anterior communicating a.
Ophthalmic a.
Internal carotid a.
Middle cerebral a.
Posterior communicating a.
Posterior cerebral a.
Superior cerebellar a.
Pontine branches
Basilar a.
Anterior inferior cerebellar a.
Vertebral a.
Anterior spinal a.
Posterior inferior cerebellar a.
Vertebral a.
Posterior spinal a.

FIGURE 7.43 ● Blood vessels (left side) and cranial nerves (right side) on the inferior surface of the brain. Inferior view.

12. Gently separate the frontal lobes and observe that the anterior cerebral arteries are joined across the midline by the **anterior communicating artery**.
13. Identify the **cerebral arterial circle (circle of Willis)**, which is formed by the posterior cerebral, posterior communicating, internal carotid, anterior cerebral, and anterior communicating arteries. *Note that the cerebral arterial circle essentially forms an anastomosis in the brain ensuring adequate blood supply to all regions.*

## Cranial Nerves

ATLAS 7.27A, 7.32; VIDEO 7.11.3

***Dissection Note:*** It is important to note that the cranial nerves are called such because of their interaction with the skull, or cranium, and not because they originate off the brain. In the following sequence, we will review the **12 cranial nerves (CN)** by name and number from an inferior view of the brain. The foramen associated with each cranial nerve will be reviewed in the next dissection.

1. Refer to FIGURE 7.43.
2. On the rostral (anterior) inferior surface of the brain, identify the **olfactory bulb and tract** and, if visible, the **olfactory nerve (CN I)**, which consists of a bundle of small nerve fibers originating from the olfactory bulb. *Note that the olfactory nerve fibers are probably not visible because they were likely torn during the separation of the brain from the anterior cranial fossa.*
3. Identify the **optic nerve (CN II)** passing bilaterally through the **optic chiasm**. The optic chiasm is the point where visual information from the medial retina (lateral visual field) of each eye crosses to the contralateral side of the brain prior to reaching the **optic tracts**.

4. Identify the **oculomotor nerve (CN III)** emerging from the midbrain between the cerebral peduncles, which connect the cerebrum to the midbrain of the brainstem. Observe that the oculomotor nerve exits the brain between the posterior cerebral artery and the superior cerebellar artery, a potential site of nerve entrapment.
5. Identify the thin **trochlear nerve (CN IV)** and follow it posteriorly around the lateral aspect of the brainstem to where it originates from the posterior surface of the midbrain.
6. Identify the relatively large **trigeminal nerve (CN V)** arising from the anterolateral aspect of the pons.
7. Identify the thin **abducens (abducent) nerve (CN VI)** along the anterior (ventral) inferior surface of the pons.
8. Lateral to the origin of the abducens nerve, identify the **facial nerve (CN VII)** and **vestibulocochlear nerve (CN VIII)** near the junction of the pons with the medulla.
9. Along the lateral aspect of the medulla posteriorly, identify the **glossopharyngeal nerve (CN IX)**, **vagus nerve (CN X)**, and **spinal accessory nerve (CN XI)** all arising in sequential order. *Note that the spinal accessory nerve originates from the spinal cord but was considered a cranial nerve because it exits the base of the skull through the jugular foramen with CN IX and CN X.*
10. Medial (ventral) to CN IX, CN X, and CN XI, identify the **hypoglossal nerve (CN XII)** between the olive and pyramid of the medulla oblongata.

## Dissection Follow-up

1. Review the lobes of the brain and the cranial fossae in which they are found.
2. Review the infoldings of the dura mater and their relationships to the cerebral hemispheres and cerebellum.
3. Review the formation of the cerebral arterial circle (circle of Willis).
4. Recall the origins of the internal carotid and vertebral arteries and the route that each takes to enter the cranial cavity.
5. Review the location and name of each of the 12 cranial nerves in sequential order.
6. Preserve the brain in a bath of preservative fluid to prevent desiccation.

# CRANIAL FOSSAE

## Dissection Overview

The skull base provides support for the weight of the brain (assisted largely by CSF encasing the brain in a liquid), protection, and passage for the neurovascular structures passing in and out of the skull. The skull base is subdivided into three cranial fossae, or depressions, each with unique features and contents, with the anterior located most superiorly and the posterior most inferiorly.

The order of dissection will be as follows: The bones of the floor of the cranial cavity will be studied, and the boundaries of the cranial fossae will be identified. The vessels and the nerves of each cranial fossa will be studied. Because the floor of the cranial cavity is covered by dura mater, the dissection is much easier if a dry skull is held next to the cadaver during dissection to permit direct observation of the foramina.

### Skeletal Anatomy

### *Skeleton of the Cranial Base*

ATLAS 7.6

On a skull with the calvaria removed, review the following skeletal features.

1. Refer to FIGURE 7.44.
2. Review the location of the three cranial fossae.
3. Within the anterior cranial fossa, identify the **crista galli** and **cribriform plate** of the **ethmoid bone** located between the **orbital plate of the frontal bones**.
4. Observe that the **anterior cranial fossa** is separated from the **middle cranial fossa** by the right and left **sphenoidal crests** and the **sphenoidal limbus** of the **lesser wing of the sphenoid bone**.
5. Observe that the middle cranial fossa is separated from the **posterior cranial fossa** by the **petrous ridge** of the right and left temporal bones and the **dorsum sellae**. *Note that the tentorium cerebelli is attached to the superior border of the petrous part of the temporal bone and it forms the roof of the posterior cranial fossa.*

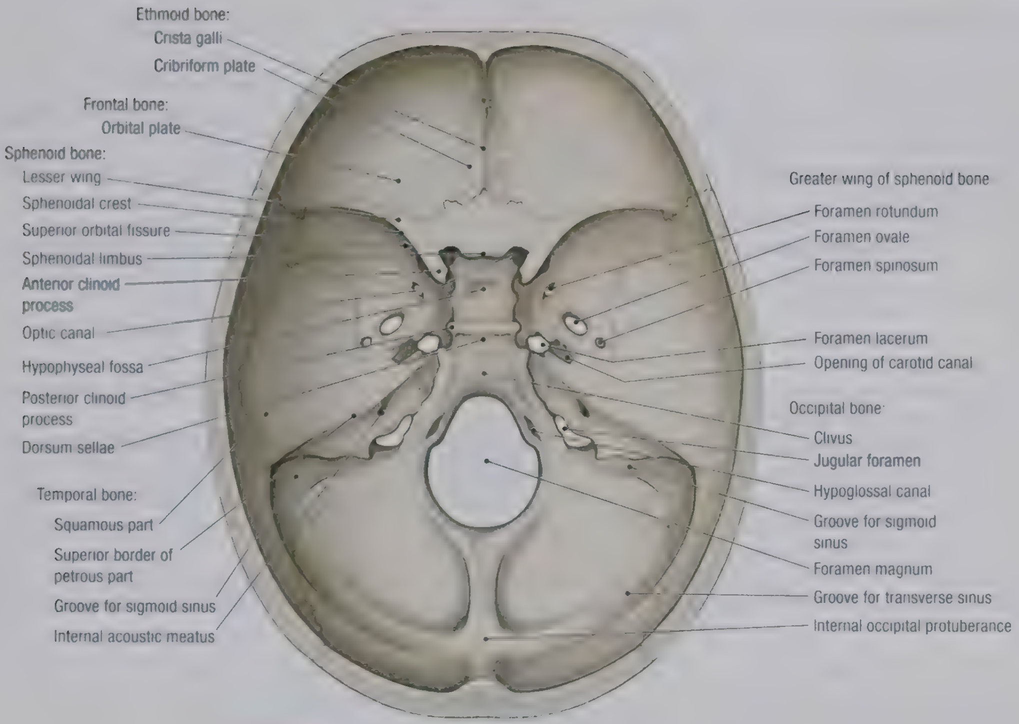

Ethmoid bone:
Crista galli
Cribriform plate
Frontal bone:
Orbital plate
Sphenoid bone:
Lesser wing
Sphenoidal crest
Superior orbital fissure
Sphenoidal limbus
Anterior clinoid process
Optic canal
Hypophyseal fossa
Posterior clinoid process
Dorsum sellae
Temporal bone:
Squamous part
Superior border of petrous part
Groove for sigmoid sinus
Internal acoustic meatus
Greater wing of sphenoid bone
Foramen rotundum
Foramen ovale
Foramen spinosum
Foramen lacerum
Opening of carotid canal
Occipital bone:
Clivus
Jugular foramen
Hypoglossal canal
Groove for sigmoid sinus
Foramen magnum
Groove for transverse sinus
Internal occipital protuberance

FIGURE 7.44 ● Features of the cranial fossae. Superior view.

### *Sphenoid Bone*

ATLAS 7.6, 7.11

1. Refer to FIGURE 7.44.
2. Observe that the posterior aspect of the anterior cranial fossa is formed by the **lesser wing** of the **sphenoid bone**.
3. Identify the **superior orbital fissure** between the lesser wing and the **greater wing of the sphenoid**. Pass a pipe cleaner through the opening and verify that the superior orbital fissure connects the orbit with the cranial cavity.
4. From an anterior perspective through the orbit, identify the smooth round opening of the **optic canal** superior and medial to the superior orbital fissure. Pass a pipe cleaner through the optic canal and observe that it passes medial to the **anterior clinoid process** within the cranial cavity.
5. In the midline of the sphenoid bone, identify the **hypophyseal fossa (part of the sella turcica)** and recall that this is the location of the pituitary gland.
6. Observe that the hypophyseal fossa is positioned between the two **anterior clinoid processes** anteriorly and the two **posterior clinoid processes** posteriorly.
7. Lateral to the sella turcica, within the floor of the middle cranial fossa, identify the oval-shaped **foramen ovale**.
8. Observe that the foramen ovale is positioned anteromedially to the small round opening of the **foramen spinosum**, the entrance point of the middle meningeal artery. Observe that grooves formed by the middle meningeal artery are visible within the middle cranial fossa emanating from the foramen spinosum.
9. Within the middle cranial fossa anteriorly and medially, identify the **foramen rotundum** inferior to the superior orbital fissure.
10. Identify the **foramen lacerum**, which is formed by portions of the greater wing of the sphenoid bone and the temporal bone. *Note that in the living individual, the foramen lacerum is covered by cartilage.*
11. Look through the nasal cavity from an anterior perspective and observe that the **body of the sphenoid** is visible. Observe that the sphenoid is connected to the nasal septum by the **sphenoidal crest**, a ridge on the anterior surface of the sphenoid.

### *Temporal Bone*

ATLAS 7.6, 7.10

1. Refer to FIGURE 7.44.
2. Observe that the temporal bone has a flat vertically oriented **squamous part**, and a horizontal medially oriented **petrous part**, which forms the bony protection for the middle and inner ear.
3. Observe that the petrous part forms the posterior aspect of the middle cranial fossa and the anterior aspect of the posterior cranial fossa.
4. Inferior to the petrous ridge, identify the **internal acoustic meatus**.
5. Observe that the petrous portion of the temporal bone is bordered posteriorly by the **groove for the sigmoid sinus**.

### *Occipital Bone*

ATLAS 7.6

1. Refer to FIGURE 7.44.
2. Observe that the **groove for the sigmoid sinus** is formed by both the temporal bone anteriorly and the occipital bone posteriorly and that it terminates medially at the **jugular foramen**.
3. In the center of the posterior cranial fossa, identify the largest foramen of the skull, the **foramen magnum**. Observe that the foramen magnum is bound completely by the occipital bone.
4. Within the walls of foramen magnum, identify the **hypoglossal canals** on both the right and left sides.
5. Anterior to the foramen magnum, identify the **clivus**, the smooth portion of the occipital bone posterior to the sella turcica. *Note that the clivus is positioned anterior to the pons of the brainstem.*
6. Follow the groove for the sigmoid sinus laterally and observe that it is continuous with the **groove for the transverse sinus**. Observe that the right and left grooves for the transverse sinuses meet posteriorly at the **internal occipital protuberance**.

## Dissection Instructions

### Anterior Cranial Fossa

ATLAS 7.26; VIDEO 7.12.1

1. Refer to FIGURE 7.45.
2. On the right side of the cadaver only, use a probe to loosen the dura mater along the cut edge of the frontal bone. Grasp the dura mater and pull it posteriorly as far as the lesser wing of the sphenoid bone.
3. Use scissors to detach the dura mater along the sphenoidal crest and along the midline of the anterior cranial fossa and place it in the tissue container.
4. Observe that the sphenoparietal venous sinus is located along the sphenoidal crest and that its lumen may now be visible where you detached the dura mater.
5. Identify the three bones that participate in the formation of the **anterior cranial fossa**: sphenoid bone, ethmoid bone, and frontal bone.
6. Identify the **crista galli** in the midline of the anterior cranial fossa and recall that before the brain was removed, the falx cerebri was attached here and that the frontal lobe of the brain rested on the orbital part of the frontal bone. *Note that the orbital part of the frontal bone also forms the roof of the orbit.*
7. Identify the openings of the cribriform plate and recall that the **olfactory bulb** arising from the **olfactory tracts** rests on the cribriform plate and that the fibers of the **olfactory nerve (CN I)** arising from the bulb pass through these openings to enter the nasal cavity.

### Middle Cranial Fossa

ATLAS 7.26, 7.30, 7.31; VIDEO 7.12.2

1. Refer to FIGURE 7.45.
2. Identify the **middle cranial fossa** and recall that it contains the temporal lobe of the brain.
3. Observe the dura mater that covers the floor of the middle cranial fossa and hides all of the openings in the skull as well as the nerves and vessels that pass through them.
4. Identify the **middle meningeal artery** visible through the dura mater on the floor of the middle cranial fossa as a dark line extending laterally from the deepest point of the middle cranial fossa.
5. Grasp the dura mater along the sphenoidal crest and peel it posteriorly as far as the superior border of the petrous part of the temporal bone. Make an effort to not disrupt the nerves lying deep to the dura mater medially or the branches of the middle meningeal artery laterally. Use a probe to tease the proximal part of middle meningeal artery away from the dura mater and leave it in the skull.
6. Clean the middle meningeal artery within the middle cranial fossa and observe that it enters the middle cranial fossa by passing through the **foramen spinosum**.
7. Use scissors to detach the dura mater along the superior border of the petrous part of the temporal bone and place it in the tissue container. Pay attention to not cut the cranial nerves that cross the

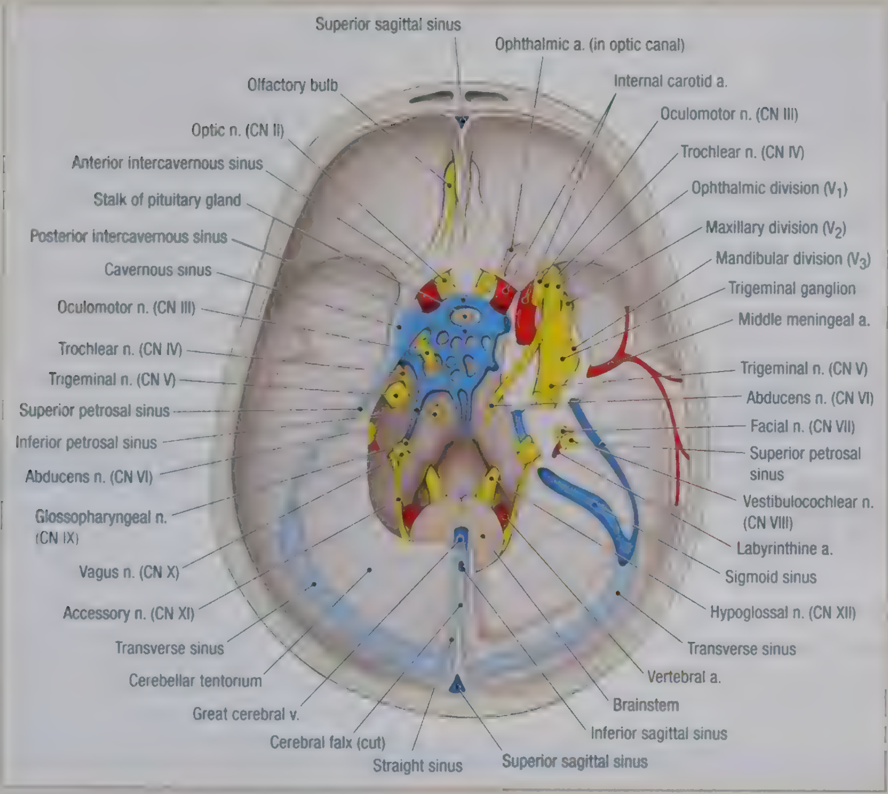

Superior sagittal sinus
Ophthalmic a. (in optic canal)
Internal carotid a.
Olfactory bulb
Oculomotor n. (CN III)
Optic n. (CN II)
Trochlear n. (CN IV)
Anterior intercavernous sinus
Ophthalmic division ($V_1$)
Stalk of pituitary gland
Maxillary division ($V_2$)
Posterior intercavernous sinus
Mandibular division ($V_3$)
Cavernous sinus
Trigeminal ganglion
Oculomotor n. (CN III)
Middle meningeal a.
Trochlear n. (CN IV)
Trigeminal n. (CN V)
Trigeminal n. (CN V)
Abducens n. (CN VI)
Superior petrosal sinus
Facial n. (CN VII)
Inferior petrosal sinus
Superior petrosal sinus
Abducens n. (CN VI)
Vestibulocochlear n. (CN VIII)
Glossopharyngeal n. (CN IX)
Labyrinthine a.
Vagus n. (CN X)
Sigmoid sinus
Accessory n. (CN XI)
Hypoglossal n. (CN XII)
Transverse sinus
Transverse sinus
Cerebellar tentorium
Vertebral a.
Great cerebral v.
Brainstem
Inferior sagittal sinus
Cerebral falx (cut)
Straight sinus
Superior sagittal sinus

FIGURE 7.45 ● Cranial nerves and vessels in the cranial fossae. Superior view.

anterior end of the superior border of the petrous part of the temporal bone (oculomotor, trigeminal, trochlear, and abducens).

8. Observe that the lumen of the **superior petrosal sinus** can be seen along the line of the cut dura mater parallel to the petrous ridge.
9. Identify the two bones forming the floor of the middle cranial fossa: sphenoid and temporal.
10. Identify the **optic nerve (CN II)** passing through the **optic canal** to enter the orbit. *Note that the optic nerve is surrounded by a sleeve of dura mater as it exits the middle cranial fossa and is technically an extension of brain tissue.*
11. Use a probe to identify the **superior orbital fissure** that is located inferior to the lesser wing of the sphenoid bone. *Note that three cranial nerves (CN III, CN IV, CN VI) and part of a fourth (CN $V_1$) exit the middle cranial fossa by passing through the superior orbital fissure.*
12. Refer to FIGURE 7.45 and to FIGURE 7.46.
13. Identify the **oculomotor nerve (CN III)** where it passes over the superior border of the petrous part of the temporal bone to pass anteriorly within the lateral wall of the cavernous sinus.
14. Identify the **trochlear nerve (CN IV)** where it courses anteriorly within the lateral wall of the cavernous sinus immediately inferior to the oculomotor nerve. *Note that the trochlear nerve is a very small nerve often found in a sleeve of dura mater at the anterior end of the tentorial notch. CN IV may have been cut during brain removal but should be intact farther anteriorly.*
15. Identify the **abducens nerve (CN VI)** where it enters the dura mater covering the clivus of the occipital bone. Observe that the abducens nerve passes anteriorly within the cavernous sinus in close relationship to the lateral surface of the internal carotid artery.
16. Identify the **ophthalmic division of the trigeminal nerve (CN $V_1$)** where it passes through the superior orbital fissure. Observe that the ophthalmic division of the trigeminal nerve arises from the trigeminal ganglion and passes anteriorly along the lateral wall of the cavernous sinus inferior to the trochlear nerve.

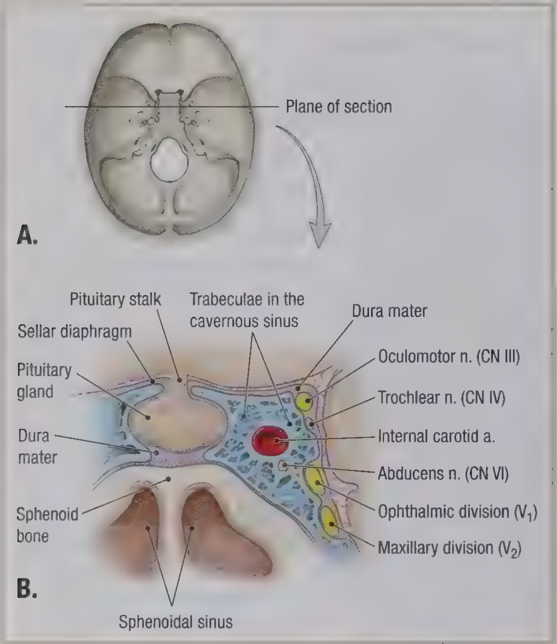


FIGURE 7.46 ● **A.** Plane of section of the middle cranial fossa. Superior view. **B.** Coronal section through the cavernous sinus. Posterior view.

17. Use a probe to clean the nerves that pass through the superior orbital fissure.
18. Use blunt dissection to further remove the tightly adhered dura mater overlying the cavernous sinus. Observe that three nerves are located along the lateral wall of the cavernous sinus (CN III, IV, $V_1$) and that one is within the cavernous sinus (CN VI).
19. Identify the **trigeminal nerve (CN V)** where it crosses the superior border of the petrous part of the temporal bone.
20. Follow the trigeminal nerve anteriorly and carefully remove the overlying dura mater to identify the **trigeminal ganglion.**
21. Use a probe to define the three divisions (nerves) that arise from the anterior border of the trigeminal ganglion (ophthalmic [CN $V_1$], maxillary [CN $V_2$], and mandibular [CN $V_3$]). *Note that the three divisions of the trigeminal nerve are named according to their region of distribution and are numbered from superior to inferior as they arise from the trigeminal ganglion.*
22. Identify the **maxillary division of the trigeminal nerve (CN $V_2$)** and follow it anteriorly to the **foramen rotundum** where it exits the middle cranial fossa. Observe that the maxillary division courses along the lateral wall of the cavernous sinus just inferior to the ophthalmic division of the trigeminal nerve (CN $V_1$).
23. Identify the **mandibular division of the trigeminal nerve (CN $V_3$)** and follow it inferiorly to the **foramen ovale** where it exits the middle cranial fossa to enter the infratemporal fossa.
24. Return to the area of the cavernous sinus and use a probe to retract the cranial nerves and identify **the internal carotid artery**. Observe that the internal carotid artery enters the cranial cavity by passing through the **carotid canal**.
25. Observe that the internal carotid artery makes a sagittally oriented S-shaped bend in the cavernous sinus and emerges near the optic nerve. *Note that cranial nerves III, IV, $V_1$, $V_2$, and VI cross the lateral side of the internal carotid artery. Among this group of nerves, the abducens nerve (CN VI) is most closely related to the internal carotid artery.*

**CLINICAL CORRELATION**

**Cranial Base Fracture**

ATLAS 7.30, 7.34

In fractures of the cranial base of the skull, the internal carotid artery may rupture within the cavernous sinus. As a result of the release of arterial blood into the cavernous sinus, the space dilates and creates an abnormal reflux of blood from the cavernous sinus into the nearby venous structures. Increased ophthalmic venous pressure results in eyeball extrusion (exophthalmos), engorgement of the conjunctiva (chemosis), and possible compression of cranial nerves III, IV, $V_1$, $V_2$, and VI.

26. Identify the region of the **hypophyseal fossa.** Observe that the hypophyseal fossa is covered by the **sellar diaphragm (diaphragma sellae)**, a dural infolding.
27. Identify the stalk of the pituitary gland, which passes through an opening in the sellar diaphragm. Recall that the pituitary gland is located in the hypophyseal fossa inferior to the sellar diaphragm.
28. Identify the location of the **anterior and posterior intercavernous sinuses**, two small dural venous sinuses anterior and posterior to the stalk of the pituitary gland. *Note that the intercavernous sinuses connect the right and left cavernous sinuses across the midline.*

## Posterior Cranial Fossa

ATLAS 7.26, 7.28; VIDEO 7.12.3

***Dissection Note:*** The features of the posterior cranial fossa will be studied with the dura mater intact.

1. Refer back to FIGURE 7.45.
2. Identify the posterior cranial fossa and recall that it contains the cerebellum and the brainstem. Observe that at the foramen magnum, the **brainstem**

becomes continuous with the **cervical spinal cord**, which is now visible with the brain removed.

3. Identify the **facial nerve (CN VII)** and the **vestibulocochlear nerve (CN VIII)** where they enter the internal acoustic meatus.
4. Identify the **glossopharyngeal nerve (CN IX)**, **vagus nerve (CN X)**, and **accessory nerve (CN XI)** where they enter the jugular foramen.

***Dissection Note:*** Because CN IX and X are formed by rootlets, it is difficult to distinguish one nerve from the other as they enter the jugular foramen. However, the cervical root of the accessory nerve can be positively identified because it enters the posterior cranial fossa through the foramen magnum and crosses the inner surface of the occipital bone.

5. Review the course of the transverse sinus and sigmoid sinus. Observe that the sigmoid sinus ends at the jugular foramen posterior to the exit point of CN IX, X, and XI.
6. Identify the **hypoglossal nerve (CN XII)** where it enters the **hypoglossal canal**.
7. On the left (undissected) side of the cranial cavity, identify the cranial nerves in order from anterior to posterior.

## Dissection Follow-up

1. Review the bones that form the floor of the cranial cavity.
2. In the skull, review the openings (foramina and fissures) through which the cranial nerves pass.
3. In the cadaver, review the course of each cranial nerve and name the opening through which each passes to exit the cranial cavity.
4. If the brain is still available, review the cranial nerves and severed vessels on both the brain and the cadaver.
5. Review the path and pattern of dural venous sinus drainage in the cadaver.
6. Preserve the brain in a bath of preservative fluid to prevent desiccation.
7. Return any reflected tissue back to anatomical position.
8. Wrap the head with a moist towel or wrapping soaked with embalming fluid or wetting solution to prevent desiccation of the exposed meninges and brain.

# ORBIT

## Dissection Overview

The orbit contains the eyeball and extraocular muscles. The eyeball is about 2.5 cm in diameter and occupies the anterior half of the orbit. The posterior half of the orbit contains fat, extraocular muscles, branches of cranial nerves, and blood vessels. Some vessels and nerves pass through the orbit to reach the scalp and face.

The roof of the orbit is related to the anterior cranial fossa, and the floor of the orbit is related to the maxillary sinus as shown in FIGURE 7.47. The medial wall of the orbit is related to the ethmoid air cells. The part of the ethmoid bone that forms the medial wall is paper-thin, and for this reason, it is called the lamina papyracea. The lateral wall of the orbit is the thickest wall of the orbit as it has the largest role in protecting the eye.

The order of dissection will be as follows: The bones of the orbit will be studied. On the right side only, the floor of the anterior cranial fossa (roof of the orbit) will be removed and the right orbit will be dissected from a superior approach. CN III, IV, $V_1$, and VI will be followed through the superior orbital fissure into the orbit. The extraocular muscles will be identified. On the left side only, the anatomy of the eyelid will be studied. The orbit will be dissected from an anterior approach and the eyeball will be removed. The attachments of the extraocular muscles will be studied.

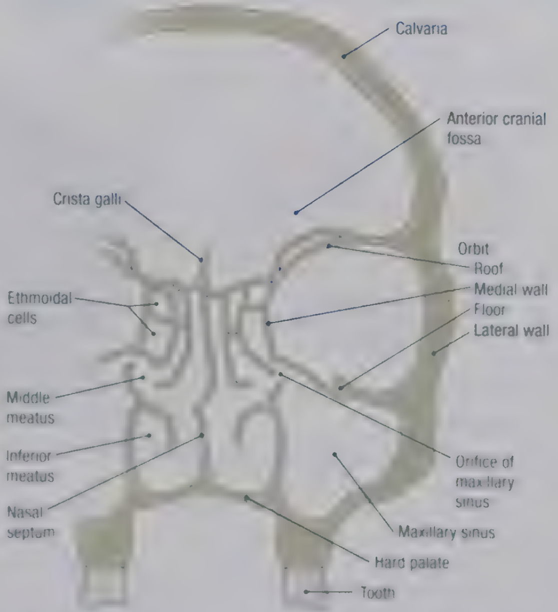


FIGURE 7.47 ● Coronal section of the skull. Anterior view.

## Skeletal Anatomy

### *Skeleton of the Orbit*

ATLAS 7.36A

Refer to a skull and identify the bones that participate in forming the walls of the orbit.

1. Refer to FIGURE 7.48.
2. From an anterior perspective, identify the orbital margin, noting the presence of the **supraorbital notch** along the superior margin. Observe that the bones of the orbit form a four-sided pyramid with the base of the pyramid formed by the **orbital margin** and the apex of the pyramid at the **optic canal**.
3. Identify the gap of the **superior orbital fissure** between the **lesser wing** and **greater wing of the sphenoid bone**.
4. Identify the round opening of the **optic canal** superomedial to the superior orbital fissure.
5. Identify the **inferior orbital fissure**, a gap between the maxilla and the greater wing of the sphenoid bone.
6. The bones of the orbit are lined with periosteum called **periorbita**. At the optic canal and the superior orbital fissure, the periorbita is continuous with the dura mater of the middle cranial fossa.
7. Observe that when viewed from above, the medial walls of the two orbits are parallel to each other and about 2.5 cm apart and that the lateral walls of the two orbits form an approximate right angle to each other.
8. Identify the **roof of the orbit** formed by the **orbital plate of the frontal bone** and the **lesser wing of the sphenoid bone**.
9. Identify the **floor of the orbit** formed by the **maxilla**, **zygomatic bone**, and a small portion of the **palatine bone**.
10. On the floor of the orbit, identify the **infraorbital groove** coursing toward the **infraorbital foramen**.
11. Identify the **medial wall of the orbit** formed by the **orbital plate of the ethmoid bone**, the **lacrimal bone**, the **frontal process of the maxilla**, and small portion of the **body of the sphenoid**.
12. On the medial wall of the orbit, identify the **anterior** and **posterior ethmoidal foramina**.
13. On the anterior aspect of the medial wall of the orbit, identify the **lacrimal fossa**, a depression bordered by the **posterior lacrimal crest** posteriorly and the **anterior lacrimal crest** anteriorly. The lacrimal fossa leads to the **lacrimal canal**, which houses the nasolacrimal duct.
14. Identify the **lateral wall of the orbit** formed by the frontal process of the zygomatic bone and the orbital plate of the greater wing of the sphenoid.

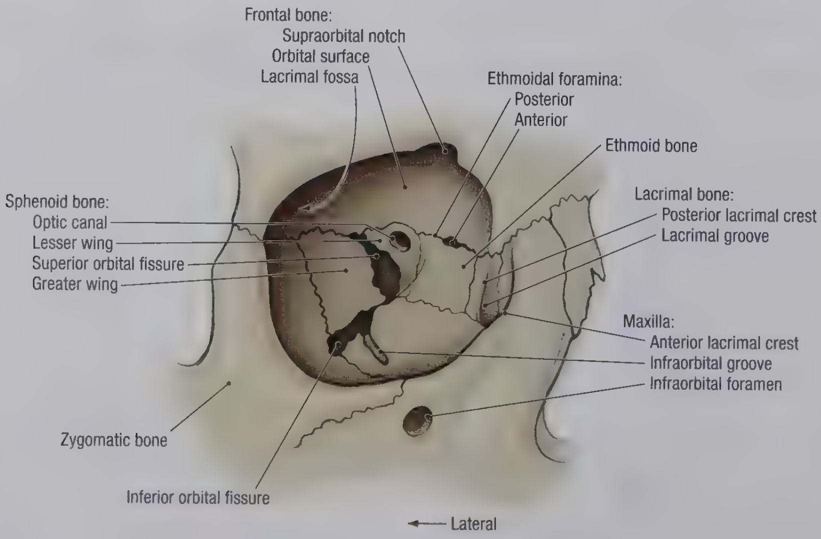

Frontal bone:
Supraorbital notch
Orbital surface
Lacrimal fossa
Ethmoidal foramina:
Posterior
Anterior
Ethmoid bone
Lacrimal bone:
Posterior lacrimal crest
Lacrimal groove
Sphenoid bone:
Optic canal
Lesser wing
Superior orbital fissure
Greater wing
Maxilla:
Anterior lacrimal crest
Infraorbital groove
Infraorbital foramen
Zygomatic bone
Inferior orbital fissure
Lateral

FIGURE 7.48 ● Walls of the right orbit. Anterior view.

## Surface Anatomy

### *Eyeball*

ATLAS 7.36B, 7.36C

Use a mirror, or recruit the assistance of your lab partner, to inspect the living eye and identify the following features.

1. Refer to FIGURE 7.49.
2. Identify the **palpebral fissure (rima)**, the opening between the eyelids, and observe that it is lined by the **eyelashes (cilia)**.
3. Identify the **medial and lateral palpebral commissures**, the points where the upper and lower eyelids join to form the **medial and lateral angles (canthi)**, or corners of the eye.
4. In the medial angle of the eye, identify the **lacrimal caruncle**, a pink fleshy bump. Observe that fluid accumulates at the **lacrimal lake**, the area surrounding the lacrimal caruncle.
5. On the medial aspect of each eyelid, identify the small bump of the **lacrimal papilla** and observe that each features a small opening at its apex, the **lacrimal puncta**.
6. Identify the **sclera**, the whitish, posterior five-sixths of the fibrous tunic of the eyeball. The sclera is continuous with the **cornea**, the transparent, anterior one-sixth of the fibrous tunic of the eyeball.
7. Identify the **iris**, the colored diaphragm seen through the cornea. Observe that the iris surrounds the **pupil**, the aperture in the center of the eye permitting light to enter the eye.
8. Evert the lower lid slightly and observe that the **margin of the eyelid** is flat and thick and that the **eyelashes (cilia)** are arranged in two or three irregular rows.

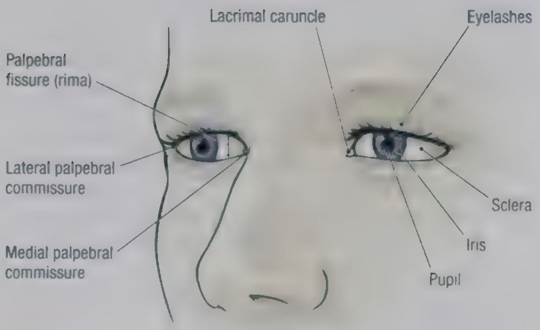

Lacrimal caruncle
Eyelashes
Palpebral fissure (rima)
Lateral palpebral commissure
Medial palpebral commissure
Sclera
Iris
Pupil

FIGURE 7.49 ● Surface anatomy of the eyes and eyelids. Anterolateral view.

### *Conjunctiva*

ATLAS 7.36B, 7.39C

Study the following features on the cadaver and relate them to the living eye.

1. Refer to FIGURE 7.50.
2. Observe that the anterior aspect of the orbit, including the eyelids and eyeball, are lined by conjunctiva, which is a specialized, protective mucous membrane.
3. Identify the **bulbar conjunctiva** on the surface of the eyeball and observe that it is continuous with the **palpebral conjunctiva**, the membrane that lines the inner surface of the eyelids.
4. The **superior and inferior conjunctival fornices** are the regions where the bulbar conjunctiva is continuous with the palpebral conjunctiva.
5. The potential space between the bulbar conjunctiva and the palpebral conjunctiva is known as the **conjunctival sac**.

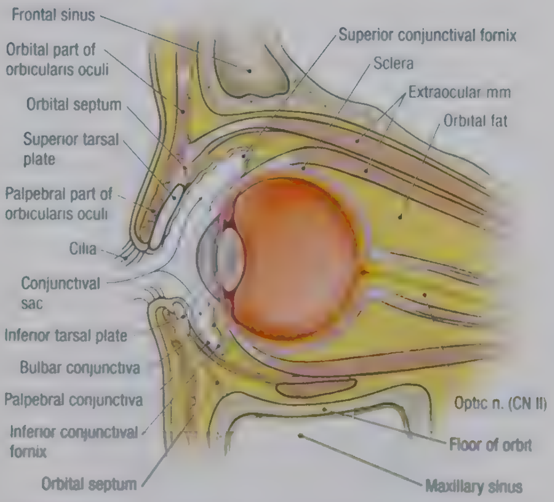

Frontal sinus
Orbital part of orbicularis oculi
Orbital septum
Superior tarsal plate
Palpebral part of orbicularis oculi
Cilia
Conjunctival sac
Inferior tarsal plate
Bulbar conjunctiva
Palpebral conjunctiva
Inferior conjunctival fornix
Orbital septum
Superior conjunctival fornix
Sclera
Extraocular mm
Orbital fat
Optic n. (CN II)
Floor of orbit
Maxillary sinus

FIGURE 7.50 ● Sagittal section through the orbit. Lateral view.

## Dissection Instructions

### Eyelid and Lacrimal Apparatus

ATLAS 7.37B, 7.37C, 7.39E; VIDEO 7.13.1

Perform the following dissection of the eyelid and lacrimal gland only in the left eye.

1. Refer to FIGURE 7.50.
2. Use a probe to raise the lateral part of the **orbital portion of the orbicularis oculi muscle** and reflect the muscle medially.
3. Raise the thin **palpebral portion of the orbicularis oculi muscle** off the underlying **tarsal plates** and reflect it medially.
4. Review the attachments of the **orbicularis oculi muscle** (see **TABLE 7.4**).
5. Refer to FIGURE 7.51.
6. Identify the **orbital septum**, a sheet of connective tissue that is attached to the periosteum at the margin of the orbit and to the tarsal plates. *Note that the orbital septum separates the superficial fascia of the face from the contents of the orbit.*
7. Identify the **tarsal plates**, which give shape to the eyelids. Retract the upper eyelid superiorly to see the shape of the **superior tarsal plate** along its posterior surface. Retract the lower eyelid inferiorly to see the shape of the **inferior tarsal plate** along its posterior surface. *Note that tarsal glands are embedded in the posterior surface of each tarsal plate, which secrete an oily substance onto the margin of the eyelid via small orifices that are located posterior to the eyelashes, which prevents the overflow of lacrimal fluid (tears).*

CLINICAL CORRELATION

### Tarsal Gland Cysts

ATLAS 7.39C

If the duct of a tarsal (meibomian) gland becomes obstructed, a chalazion (cyst) will develop. A chalazion will be located deep to the tarsal plate, between it and the conjunctiva. In contrast, a hordeolum (stye) is the inflammation of a sebaceous gland associated with the follicle of an eyelash and will be located superficial to the tarsal plate.

8. Refer to FIGURE 7.52.
9. Identify the location of the **lacrimal gland** within the lacrimal fossa.
10. To find the lacrimal gland in the cadaver, use a scalpel to cut through the orbital septum adjacent to the orbital margin in the superolateral quadrant of the left orbit.
11. Pass a probe through the incision and free the lacrimal gland from the lacrimal fossa. *Note that the lacrimal gland drains into the superior conjunctival fornix by 6 to 10 short ducts.*
12. Use a skull to identify the **lacrimal groove** at the medial side of the orbital margin. Observe that the **anterior lacrimal crest** of the maxilla forms the anterior border of the lacrimal groove. *Note that the*

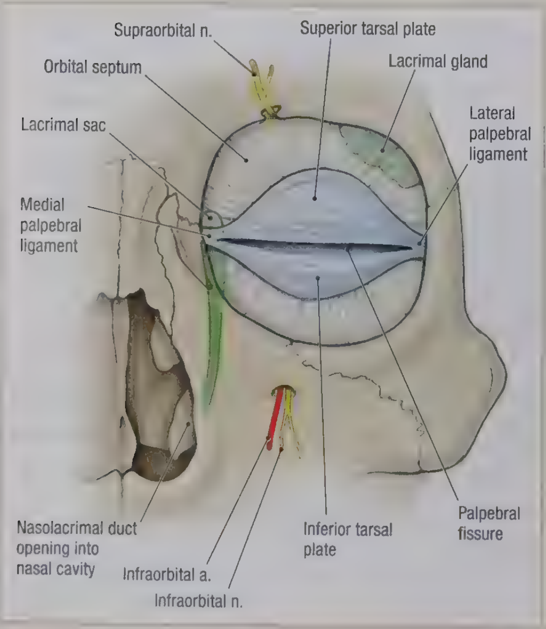

Supraorbital n.
Superior tarsal plate
Orbital septum
Lacrimal gland
Lacrimal sac
Lateral palpebral ligament
Medial palpebral ligament
Nasolacrimal duct opening into nasal cavity
Infraorbital a.
Infraorbital n.
Inferior tarsal plate
Palpebral fissure

FIGURE 7.51 ■ Orbital septum and tarsal plates of the left orbit. Anterior view.

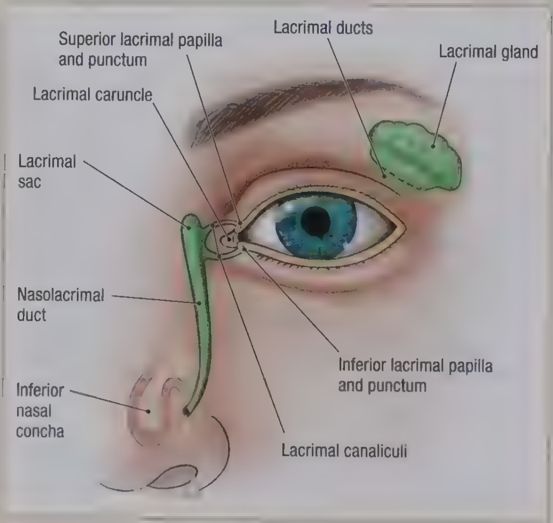

Superior lacrimal papilla and punctum
Lacrimal ducts
Lacrimal gland
Lacrimal caruncle
Lacrimal sac
Nasolacrimal duct
Inferior lacrimal papilla and punctum
Inferior nasal concha
Lacrimal canaliculi

FIGURE 7.52 ■ Components of the lacrimal apparatus of the left eye. Anterior view.

*medial palpebral ligament is attached to the anterior lacrimal crest and that the lacrimal sac lies posterior to the medial palpebral ligament in the lacrimal groove.*

13. Identify the **lacrimal puncta** on the medial aspects of the eyelids, which connect to the two **lacrimal canaliculi** that drain lacrimal fluid from the medial angle of the eye into the lacrimal sac. *Note that the nasolacrimal duct extends inferiorly from the lacrimal sac and enters the inferior meatus of the nasal cavity.*
14. Identify the location of the **lacrimal gland** in the superior lateral aspect of the orbit. *Note that lacrimal fluid flows from the lacrimal gland across the eyeball to the medial angle of the eye. During crying, excess lacrimal fluid cannot be emptied through the lacrimal canaliculi and tears overflow the lower eyelids. Increased drainage of tears into the nasal cavity stimulates sniffling, which is characteristic of crying.*

## Right Orbit from the Superior Approach

ATLAS 7.38A, 7.38C; VIDEO 7.13.2

***Dissection Note:*** Dissect only the right orbit from the superior approach. Wear eye protection for all steps that require the use of bone cutters.

1. Refer to FIGURE 7.53.
2. In the floor of the anterior cranial fossa, tap the **orbital plate of the frontal bone** with the side of the bone cutters until the bone cracks (**Cut 1**). Use forceps to pick out the bone fragments.
3. Enlarge the opening in the **roof of the orbit** with the bone cutters (**Cut 2**) and remove the roof of the orbit as far anteriorly as the superior orbital margin.
4. Anteriorly, the **frontal sinus** of the frontal bone may extend into the roof of the orbit. Medially, the **ethmoidal cells** of the ethmoid bone may extend into the roof of the orbit. If either sinus extends into the orbit in your cadaver, use a probe to push the mucous membrane that lines the sinuses away from the roof of the orbit and remove the associated layer of thin bone to open the orbit (**Cut 3**).

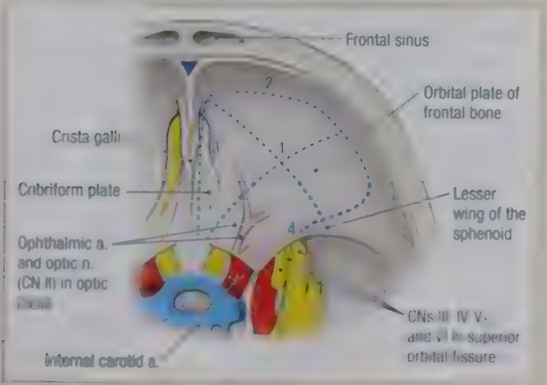

Frontal sinus
2
Orbital plate of frontal bone
Crista galli
1
3
Cribriform plate
Lesser wing of the sphenoid
4
Ophthalmic a. and optic n. (CN II) in optic canal
CNs III, IV, V₁ and VI in superior orbital fissure
Internal carotid a.

FIGURE 7.53 ● Superior approach to the right orbit. Superior view.

5. Identify the **periorbita**, the membrane just deep to the roof of the orbit that lines the bones of the orbit.
6. Push a probe posteriorly between the roof of the orbit and the periorbita. The probe should pass inferior to the **lesser wing of the sphenoid bone**, through the **superior orbital fissure**, and into the middle cranial fossa. Elevate the probe to break the lesser wing of the sphenoid bone.
7. Use bone cutters to remove the fragments of the lesser wing of the sphenoid bone (**Cut 4**).
8. Chip away the roof of the **optic canal** and remove the **anterior clinoid process**.
9. Examine the periorbita and observe that the frontal nerve may be visible through it.
10. Use scissors to incise the periorbita from the apex of the orbit to the midpoint of the superior orbital margin avoiding the frontal nerve.
11. Use forceps to lift the periorbita off deeper structures and make a transverse incision through the periorbita close to the superior orbital margin. Use a probe to tease open the flaps of periorbita and use scissors to remove them from the orbit.

## Contents of the Orbit

ATLAS 7.38A, 7.38C, 7.44A; VIDEO 7.13.3

***Dissection Note:*** Blunt dissection with a fine probe and forceps is recommended from this point onward in the dissection of the right orbit. Use the forceps to pick out the fat that fills the intervals between muscles, nerves, and vessels.

1. Refer to FIGURE 7.54.
2. Observe that three nerves enter the apex of the orbit by passing superior to the extraocular muscles.
3. Identify the **frontal nerve** (a branch of CN $V_1$) that courses from the apex of the orbit toward the superior orbital margin. Trace the frontal nerve anteriorly and observe that it divides into the **supratrochlear nerve** and the **supraorbital nerve**.
4. On the lateral aspect of the orbit, identify the **lacrimal nerve** (a branch of CN $V_1$), which passes through the superior orbital fissure lateral to the frontal nerve.
5. Follow the lacrimal nerve anterolaterally toward the lacrimal gland. Observe that the lacrimal nerve is much smaller than the frontal nerve.
6. On the medial aspect of the orbit, identify the **trochlear nerve**, which passes through the superior orbital fissure medial to the frontal nerve.
7. Follow the trochlear nerve to the superior border of the **superior oblique muscle**, which it innervates. *Note that the trochlear nerve usually enters the superior border of the superior oblique muscle in its posterior one-third.*

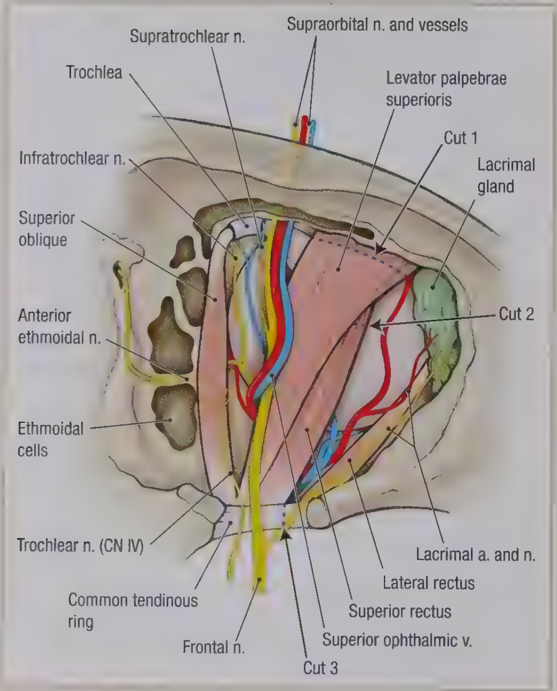

Supratrochlear n.
Supraorbital n. and vessels
Trochlea
Levator palpebrae superioris
Cut 1
Lacrimal gland
Infratrochlear n.
Superior oblique
Anterior ethmoidal n.
Cut 2
Ethmoidal cells
Trochlear n. (CN IV)
Lacrimal a. and n.
Lateral rectus
Common tendinous ring
Superior rectus
Superior ophthalmic v.
Frontal n.
Cut 3

FIGURE 7.54 ■ Superficial dissection of the right orbit. Superior view

8. While preserving the nerves, use forceps to pick out lobules of fat and expose the superior surface of the **levator palpebrae superioris muscle**. The levator palpebrae superioris muscle attaches to the upper eyelid, which it elevates.
9. Transect the levator palpebrae superioris muscle as far anteriorly as possible (**Cut 1**) and reflect it posteriorly.
10. Identify the **superior rectus muscle** that lies immediately inferior to the levator palpebrae superioris muscle. Clean the superior rectus muscle and observe that it is attached to the eyeball by a thin, broad tendon.
11. Transect the superior rectus muscle close to the eyeball (**Cut 2**) and reflect it posteriorly.
12. Identify the **superior ophthalmic vein** and observe that at the medial angle of the eye, the superior ophthalmic vein anastomoses with the angular vein, a tributary of the facial vein.
13. To increase visibility of the other structures within the orbit, the superior ophthalmic vein may be removed.
14. On the lateral side of the orbit, identify the **lateral rectus muscle**.
15. Follow the lateral rectus muscle posteriorly and identify the **common tendinous ring**. *Note that the lateral rectus muscle arises by two heads from the common tendinous ring.*

CLINICAL CORRELATION

### Cavernous Sinus Thrombosis

ATLAS 7.44B

Anastomoses between the facial vein and the superior and inferior ophthalmic veins via the angular vein are of clinical importance because infections of the upper lip, cheeks, and forehead may spread into the cavernous sinus leading to cavernous sinus thrombosis. Thrombosis, a clot in the cavernous sinus, resulting from the facial infection may lead to involvement of the abducens nerve and dysfunction of the lateral rectus muscle or possible obstruction of the venous drainage of the retina leading to slow painless loss of vision.

16. Observe that the common tendinous ring surrounds the optic canal and part of the superior orbital fissure and that it is the posterior attachment of the four rectus muscles, two of which have now been identified.
17. Cut the common tendinous ring between the attachments of the superior rectus and lateral rectus muscles (**Cut 3**). *Note that the optic nerve (CN II), nasociliary nerve, oculomotor nerve (CN III), and abducens nerve (CN VI) pass through the common tendinous ring.*
18. Refer to FIGURE 7.55.
19. Identify the **ophthalmic artery** where it branches from the internal carotid artery.

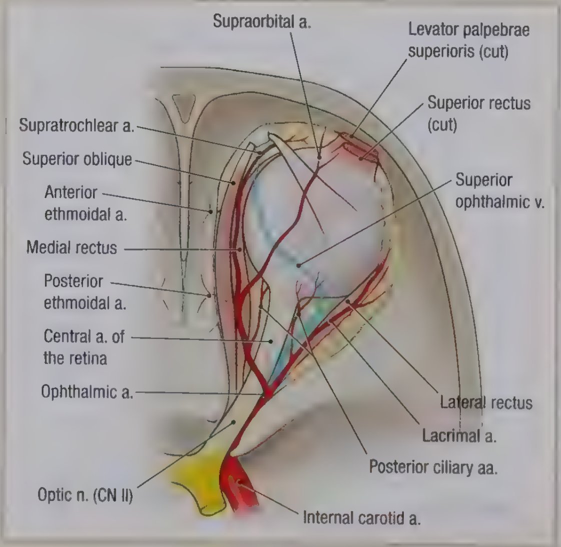

Supraorbital a.
Levator palpebrae superioris (cut)
Superior rectus (cut)
Supratrochlear a.
Superior oblique
Superior ophthalmic v.
Anterior ethmoidal a.
Medial rectus
Posterior ethmoidal a.
Central a. of the retina
Ophthalmic a.
Lateral rectus
Lacrimal a.
Posterior ciliary aa.
Optic n. (CN II)
Internal carotid a.

FIGURE 7.55 ■ Branches of the ophthalmic artery in the right orbit. Superior view.

20. Observe that during its course through the orbit, the ophthalmic artery usually crosses superior to the optic nerve to reach the medial wall of the orbit.
21. Near the medial wall of the orbit, identify the terminal branches of the ophthalmic artery, the **supraorbital** and **supratrochlear arteries**.
22. Use a probe to try and gently tease out the **posterior ciliary arteries** that supply the eyeball arising from the ophthalmic artery.
23. On the lateral aspect of the orbit, look for the **lacrimal artery** supplying the **lacrimal gland**.
24. Refer to FIGURE 7.56.
25. Identify the **lacrimal gland** in the anterolateral aspect of the orbit. If necessary, remove additional bone from the orbital plate of the frontal bone using bone cutters to further expose the lacrimal gland.
26. Clean the lateral rectus muscle and identify the **abducens nerve (CN VI)** on its medial surface near the apex of the orbit. Observe that the abducens nerve passes between the two heads of the lateral rectus muscle and enters the medial surface of the lateral rectus muscle.
27. On the medial side of the orbit, clean the **superior oblique muscle** and trace it anteriorly. Observe that the tendon of the superior oblique muscle passes through the **trochlea**, bends at an acute angle, and attaches to the posterolateral portion of the eyeball.
28. Identify the **medial rectus muscle** inferior to the superior oblique muscle belly about midway up the height of the eyeball on the medial aspect of the orbit.

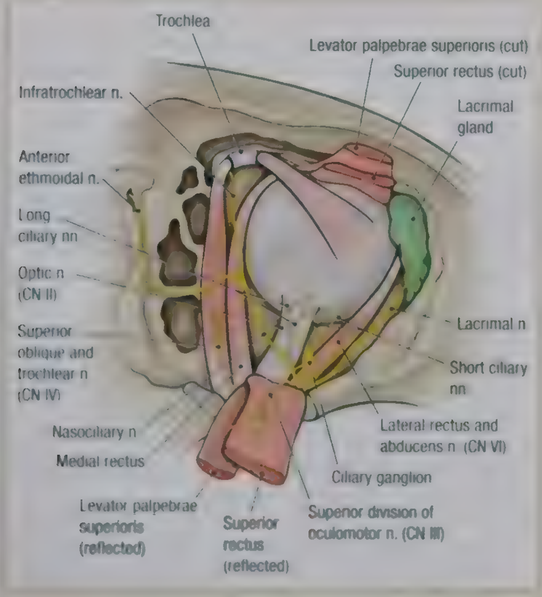

Trochlea
Levator palpebrae superioris (cut)
Superior rectus (cut)
Infratrochlear n.
Lacrimal gland
Anterior ethmoidal n.
Long ciliary nn
Optic n (CN II)
Superior oblique and trochlear n (CN IV)
Lacrimal n
Short ciliary nn
Nasociliary n
Lateral rectus and abducens n (CN VI)
Medial rectus
Ciliary ganglion
Levator palpebrae superioris (reflected)
Superior rectus (reflected)
Superior division of oculomotor n. (CN III)

FIGURE 7.56 ● Deep dissection of right orbit. Superior view.

29. In the middle cranial fossa, identify the **oculomotor nerve** running along the lateral wall of the cavernous sinus.
30. Follow the oculomotor nerve through the superior orbital fissure into the orbit where it branches into two divisions: the **superior division**, which innervates the levator palpebrae superioris, and the superior rectus muscles, and the **inferior division**, which innervates the medial rectus, inferior rectus, and inferior oblique muscles. *Note that the inferior rectus and inferior oblique muscles are not easily seen from the superior approach and thus will be identified from the anterior approach.*
31. Review the attachments, actions, and innervations of the extraocular muscles on the eyeball (see **TABLE 7.6**).
32. Identify the **nasociliary nerve**, which is a branch of $V_1$. Observe that the nasociliary nerve courses obliquely through the orbit from lateral to medial and that it is much smaller than the frontal nerve.
33. Identify the large **optic nerve (CN II)** reaching the posterior aspect of the eye at an angle. *Note that the optic "nerve" is actually a brain tract surrounded by the three meningeal layers: dura mater, arachnoid mater, and pia mater.*
34. Observe that the nasociliary nerve crosses superior to the optic nerve and gives several **long ciliary nerves** to the posterior aspect of the eyeball.
35. Follow the nasociliary nerve toward the medial wall of the orbit and identify the **anterior ethmoidal nerve**, which passes through the anterior ethmoidal foramen to supply part of the mucous membrane in the nasal cavity. *Note that the terminal branch of the anterior ethmoidal nerve is the external nasal nerve that innervates the skin at the tip of the nose.*
36. Identify the **ciliary ganglion,** a small parasympathetic ganglion located between the optic nerve and the lateral rectus muscle. Observe that **short ciliary nerves** connect the ciliary ganglion to the posterior surface of the eyeball.

## Left Orbit from the Anterior Approach

ATLAS 7.37A, 7.39A, 7.43B; VIDEO 7.13.4

1. Refer back to FIGURE 7.50 and FIGURE 7.51.
2. Use a probe to explore the **conjunctival sac** via the **palpebral fissure**. Verify that the bulbar conjunctiva is attached to the sclera and that it is continuous with the palpebral conjunctiva on the inner surface of the eyelids.
3. Use sharp dissection to remove both eyelids and the orbital septum.
4. Examine the orbit from the anterior view and observe that the **lacrimal gland** is located superolaterally and that the **trochlea** is located superomedially.

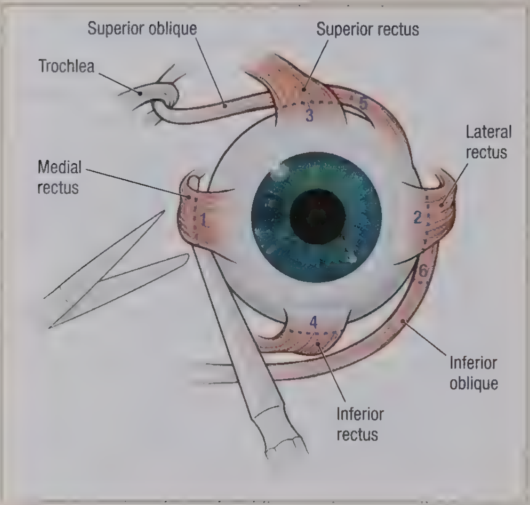

Superior oblique
Superior rectus
Trochlea
3
5
Lateral rectus
Medial rectus
1
2
6
4
Inferior oblique
Inferior rectus

FIGURE 7.57 ■ Transection of the left extraocular muscles. Anterior view.

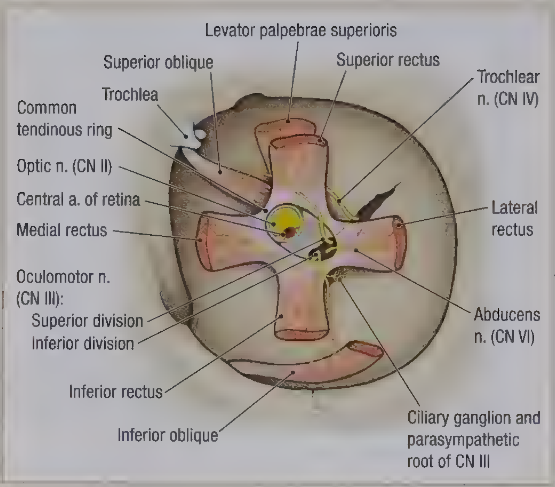

Levator palpebrae superioris
Superior oblique
Superior rectus
Trochlear n. (CN IV)
Trochlea
Common tendinous ring
Optic n. (CN II)
Central a. of retina
Medial rectus
Lateral rectus
Oculomotor n. (CN III):
Superior division
Inferior division
Abducens n. (CN VI)
Inferior rectus
Inferior oblique
Ciliary ganglion and parasympathetic root of CN III

FIGURE 7.58 ■ The left orbit with the eye removed. Anterior view.

5. Use blunt dissection to remove the orbital fat inferior to the eye near the orbital margin.
6. Refer to FIGURE 7.57.
7. Gently elevate the eye and identify the **inferior oblique muscle**, which is attached inferomedially.
8. Use a probe to separate the tendon of the **medial rectus muscle** from the eye and transect it with scissors (**Cut 1**).
9. Use a probe to separate the tendon of the **lateral rectus muscle** from the eye and transect it with scissors (**Cut 2**).
10. Gently depress the eye and use a probe to separate the tendon of the **superior rectus muscle** from the eye and transect it with scissors (**Cut 3**).
11. Gently elevate the eye and use a probe to separate the tendon of the **inferior rectus muscle** from the eye and transect it with scissors (**Cut 4**).
12. Use forceps to grasp the remaining anterior portion of the lateral rectus tendon and pull it anteriorly to adduct the eyeball (turn it medially).
13. Insert scissors into the orbit on the lateral side of the eyeball and transect the optic nerve.
14. Pull the eyeball farther anteriorly and transect the superior and inferior oblique tendons near the surface of the eyeball posteriorly (**Cuts 5** and **6**).
15. Remove the eyeball from the orbit.
16. Refer to FIGURE 7.58.
17. Study the enucleated orbit and use forceps to pick out lobules of orbital fat from the posterior portion of the orbit.
18. Find the nerve to the inferior oblique muscle and follow it posteriorly to the **inferior division of the oculomotor nerve (CN III)**.
19. Trace the four rectus muscles to their attachments on the **common tendinous ring**.
20. Identify the structures that pass through the common tendinous ring: the **optic nerve (CN II) and central artery of the retina, superior and inferior divisions of the oculomotor nerve (CN III), abducens nerve (CN VI)**, and **nasociliary nerve**.
21. Examine the cut surface of the optic nerve and try to identify the **central artery of the retina**, which may be seen as a dark spot on the cut surface.
22. Refer to FIGURE 7.59.
23. If the removed eyeball is in dissectible condition, use a new scalpel blade to cut it in half in the coronal plane.
24. Remove the **vitreous body** from the posteriorly located **vitreous chamber**.
25. Observe that the **lens** separates the anterior and posterior chambers of the eye. *Note that the lens may be replaced by a prosthetic implant in some cadavers.*
26. Observe that the eye is composed of three layers or tunics. Identify the **fibrous (outer) layer** composed of the sclera (posterior five-sixths) and **cornea** (anterior one-sixth).
27. Identify the **choroid, ciliary body**, and **iris** comprising the **vascular (middle) layer**.
28. Use a probe to gently move the partially detached **retina**, which forms the **nervous (inner) layer**.
29. Observe that the retina is attached posteriorly near the **optic disc (blind spot)** where the optic nerve and retinal vessels enter or leave.
30. In well-preserved specimens, it may be possible to identify the **macula**, the highest center for visual acuity in humans, along the posterior aspect of the retina.
31. When you have finished your study of the explanted eye, place it in the tissue container.

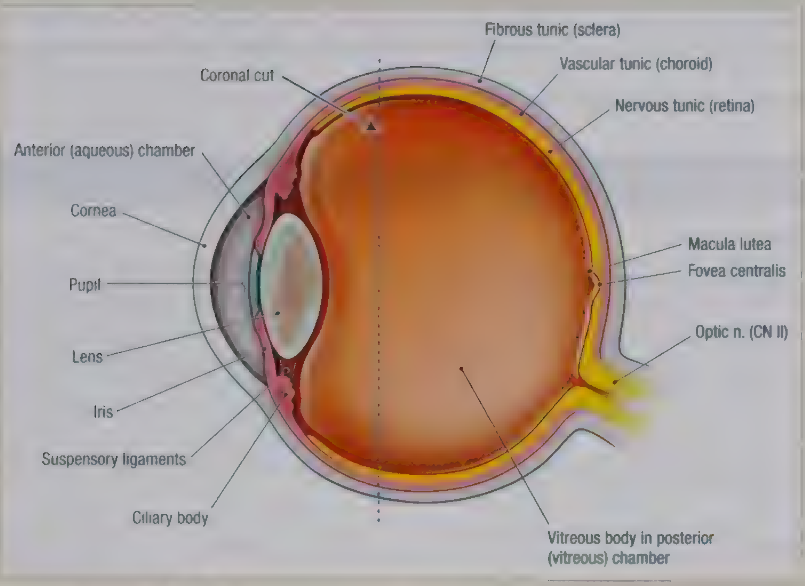

Fibrous tunic (sclera)
Vascular tunic (choroid)
Coronal cut
Nervous tunic (retina)
Anterior (aqueous) chamber
Cornea
Macula lutea
Fovea centralis
Pupil
Optic n. (CN II)
Lens
Iris
Suspensory ligaments
Ciliary body
Vitreous body in posterior (vitreous) chamber

FIGURE 7.59 • Transverse section through the right eye. Superior view.

## Dissection Follow-up

1. Use a skull to review the bones that form the margin of the orbit, the walls of the orbit, and the openings at the apex of the orbit.
2. Examine the middle cranial fossa and review the structures passing through the optic canal and the superior orbital fissure.
3. Review the path of the nerves innervating the extraocular muscles within the cavernous sinus and their relationship to the common tendinous ring as they pass through the superior orbital fissure to reach the apex of the orbit.
4. Review the origin and course of the central retinal artery and the ophthalmic artery.
5. Review the attachments and innervations of the six extraocular muscles and the levator palpebrae superioris in **TABLE 7.6**.

**TABLE 7.6 | Extraocular Muscles**

| *Muscle* | *Anterior Attachments* | *Posterior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Levator palpebrae superioris | Tarsal plate of the upper eyelid | Sphenoid bone | Elevation and retraction of the upper eyelid | Superior division of oculomotor n. (CN III) |
| Superior rectus | Sclera (anterior, superior surface) | Common tendinous ring | Elevation and adduction of the eye | |
| Superior oblique | Sclera (posterior, lateral, superior surface) | Sphenoid bone | Depression, intorsion, and abduction of the eye | Trochlear n. (CN IV) |
| Lateral rectus | Sclera (anterior, lateral surface) | Common tendinous ring | Abduction of the eye | Abducens n. (CN VI) |
| Medial rectus | Sclera (anterior, medial surface) | | Adduction of the eye | Inferior division of oculomotor n. (CN III) |
| Inferior rectus | Sclera (posterior, lateral, inferior surface) | | Depression and adduction of the eye | |
| Inferior oblique | Sclera (anterior, inferior surface) | Maxilla | Elevation, extorsion, and abduction of the eye | |

Note that the above actions are referenced from a neutral position of the eye.

Abbreviations: CN, cranial nerve; n., nerve.

6. Review the movements of the eyeball and relate each movement to the extraocular muscles that are responsible.
7. Review the ciliary ganglion and note the origin of its presynaptic parasympathetic axons and the course of its postsynaptic axons to the eyeball and state the function of the two smooth muscles that are innervated by the ciliary ganglion.
8. Return the reflected portions of tissue back to anatomical position.

# DISARTICULATION OF THE HEAD

## Dissection Overview

Recall that the cervical viscera are located with the anterior part of the neck within the pretracheal fascia. The retropharyngeal space separates the buccopharyngeal fascia, the posterior aspect of the pretracheal fascia, from the prevertebral fascia. The alar fascia subdivides the retropharyngeal space to create a potential space for spread of infection known as the danger space. In order to study the cervical viscera from a posterior approach, and to clearly see the muscles and structures surrounded by the prevertebral fascia, the head must be disarticulated or detached from the vertebral column.

The order of dissection will be as follows: The retropharyngeal space will be opened from the base of the skull superiorly to the superior thoracic aperture inferiorly. A wedge-shaped cut will be made in the occipital bone to facilitate disarticulation. The anterior aspect of the head will be reflected anteriorly off of the vertebral column while remaining attached to the cervical viscera.

## Skeletal Anatomy

### *Skeleton of the Suboccipital Region*

ATLAS 1.7C, 1.10B, 1.11, 7.5A

Refer to an articulated skeleton and identify the following.

1. Refer to FIGURE 7.60.
2. Observe that the **atlas** (C1) does not have a body and that the **axis** (C2) has the **dens (odontoid process)**, the body of C1 that became fused to C2 during development.
3. On the atlas, identify the **posterior arch** and the **posterior tubercle** at its midpoint, observing that the atlas does not have a spinous process.
4. On the atlas, identify the **anterior arch** and the **anterior tubercle** at its midpoint, observing that the atlas does not have a vertebral body. *Note that the transverse ligament of the atlas holds the dens to the anterior arch of the atlas to provide stability.*
5. On the superior aspect of C1 bilaterally, identify the horizontally orientated **superior articular facets**.
6. On an articulated skeleton, observe that the articulation between the superior articular surfaces with the **occipital condyles** at the base of the skull creates the **atlanto-occipital joint**, which allows nodding movement, or the "yes" type of motion, between the head and neck.
7. On the superior aspect of C2 bilaterally, identify the **superior articular facets**, which articulate with the **atlas**.
8. On an articulated skeleton, observe that the articulation between C1 and C2 creates the **atlantoaxial joint**, which allows rotational movement, or the "no" type of motion, between the head and neck.
9. Refer to FIGURE 7.61.
10. From an inferior view, identify the **basilar part of the occipital bone** and the small, roughened area of the

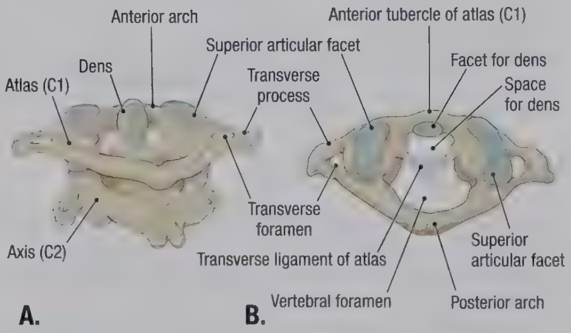

Anterior arch
Anterior tubercle of atlas (C1)
Superior articular facet
Dens
Atlas (C1)
Transverse process
Facet for dens
Space for dens
Transverse foramen
Axis (C2)
Transverse ligament of atlas
Superior articular facet
Vertebral foramen
Posterior arch
A.
B.

FIGURE 7.60 ■ Skeleton and ligaments of the atlantoaxial joint. **A.** Posterolateral view. **B.** Superior view.

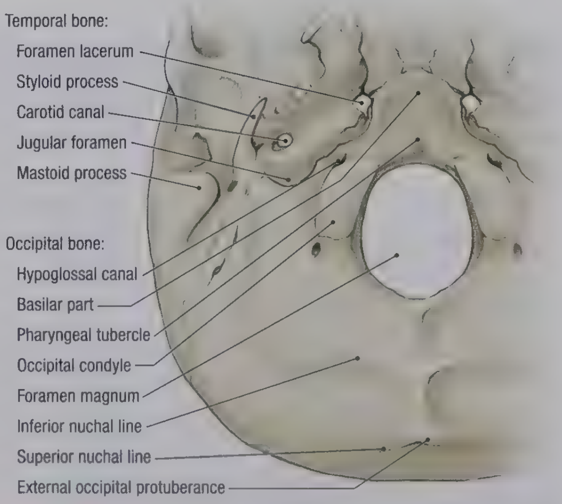

Temporal bone:
Foramen lacerum
Styloid process
Carotid canal
Jugular foramen
Mastoid process
Occipital bone:
Hypoglossal canal
Basilar part
Pharyngeal tubercle
Occipital condyle
Foramen magnum
Inferior nuchal line
Superior nuchal line
External occipital protuberance

FIGURE 7.61 ■ Temporal and occipital bones. Inferior view.

**pharyngeal tubercle** anterior to the **foramen magnum**. Recall that the foramen magnum allowed passage of the brainstem, the vertebral arteries (left and right), and cervical roots of the accessory nerves (left and right).

11. Identify the **hypoglossal canal** in the wall of foramen magnum and observe that the canal courses in the bone superior to the **occipital condyles**.
12. Identify the **external occipital protuberance** in the posterior aspect of the skull as well as the horizontally oriented **superior** and **inferior nuchal lines**.
13. Identify the **jugular foramen** and observe that it is partially formed by the more anteriorly located temporal bone and the more posteriorly located occipital bone. Recall that the glossopharyngeal nerve (CN IX), vagus nerve (CN X), accessory nerve (CN XI), and the venous blood from the sigmoid sinus draining to the internal jugular vein pass through the jugular foramen.
14. Identify the opening of the **carotid canal** medial to **the styloid process** and anterior to the jugular foramen.
15. Identify the **foramen lacerum** at the medial aspect of the carotid canal and recall that this opening is covered with cartilage in the living individual.
16. Identify the **mastoid process** and recall that this large prominence is the superior attachment of the sternocleidomastoid and posterior belly of digastric muscles.

## Dissection Instructions

### Retropharyngeal Space

ATLAS 8.21, 8.41; VIDEO 7.14.1

1. Refer to FIGURE 7.62.
2. Place the body in a supine position.
3. Return to the cervical region and bilaterally gather the ends of the cutaneous branches of the cervical plexus (transverse cervical, great auricular, lesser occipital) and reflect them posteriorly so that they remain attached to the vertebral column.
4. Clean the anterior and posterior borders of both SCMs to their superior attachments at the mastoid processes.
5. Reflect each SCM superiorly, taking care to preserve the accessory nerve.
6. Use blunt dissection to create a gap posterior to the contents of the right and left **carotid sheaths** to enter the **retropharyngeal (retrovisceral) space,** making an effort to stay posterior to the **alar fascia** in the subdivision of the **danger space**.
7. Push your fingers medially through the newly created gap until they touch in the midline or pass a blunt instrument through the space.
8. Enlarge the separation between the viscera and pretracheal fascia anteriorly and the vertebral column and prevertebral fascia posteriorly.
9. Place a probe in the retropharyngeal space posterior to the contents of the carotid sheaths so it passes

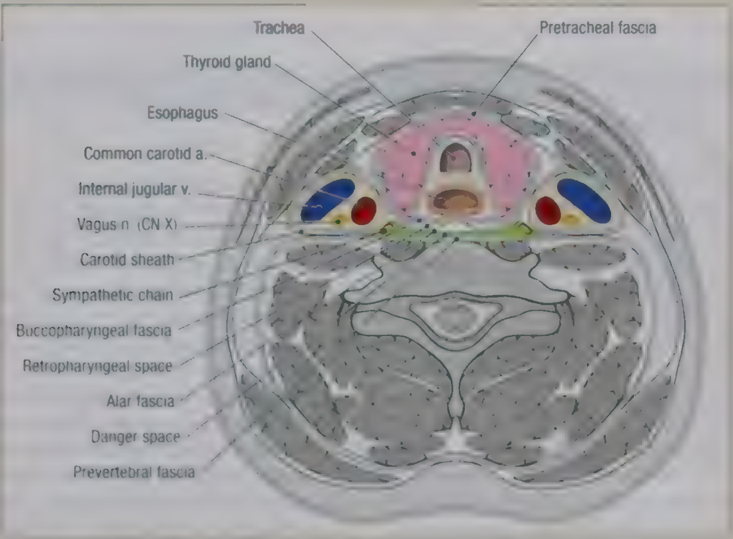


FIGURE 7.62 ■ Transverse section through the retropharyngeal space of the neck. Inferior view.

completely across the neck within the retropharyngeal space.

10. Leave the probe traversing the neck and use your fingers or another blunt instrument to confirm that the retropharyngeal space extends superiorly all the way up to the base of the skull.
11. Use your fingers or another blunt instrument to confirm that the retropharyngeal space extends inferiorly into the mediastinum of the thorax. *Note that an infection may spread from the head to the thorax within the danger space.*

## Disarticulation of the Head

ATLAS 7.6A, 8.23, 8.27; VIDEO 7.14.2

***Dissection Note:*** The head will be separated from the vertebral column at the atlanto-occipital joint after making a wedge-shaped cut in the occipital bone.

1. Refer to FIGURE 7.63.
2. With the cadaver in the supine position, rotate the head until you can identify the accessory nerve and the structures that exit the jugular foramina at the base of the skull bilaterally because you will keep them attached to the head during reflection.
3. Use a saw to make two oblique cuts through the occipital bone parallel to the petrous ridge on each side (**Cuts 1** and **2**). Internally, the saw cuts should be posterior to the jugular foramina, in order to preserve the structures passing through it, and posterior to the hypoglossal canals at the foramen magnum. Externally, the saw cuts should pass posterior to the mastoid process of the temporal bone so the attachments of the SCMs remain intact.
4. Slide a thin chisel from lateral to medial along the base of the skull adjacent to the atlanto-occipital joint to widen the space at the base of the skull.
5. Use a scalpel to cut through the atlanto-occipital joint capsules bilaterally (**Cut 3**) and then use the chisel to separate the articular surfaces of the joints. *Note that if the joint is difficult to access from the supine position, the cadaver may be rotated to the prone position.*
6. Push the head anteriorly and insert a scalpel into the most superior part of the retropharyngeal space to cut the adhered soft tissues of the longus capitis and rectus capitis anterior muscles and the anterior atlanto-occipital membrane in order to free the head for reflection (**Cut 4**).
7. Gently continue to force the head forward until it is freed from C1. *Note that if performed correctly, the head remains attached to the pharynx.*
8. With the head fully detached, but not yet reflected, identify the **sympathetic trunk** and the **superior cervical sympathetic ganglion** on the anterior surface of the cervical vertebral column.
9. Reflect the right sympathetic trunk and superior cervical ganglion with the head, cervical viscera, and associated neurovascular structures anteriorly until the chin rests on the thorax.
10. Make an effort to leave the left sympathetic trunk and associated cervical ganglion with the vertebral column and associated muscles structures posteriorly.
11. Inspect the reflected base of the skull from the posterior perspective and look for the structures associated with the jugular foramen and the hypoglossal canal.

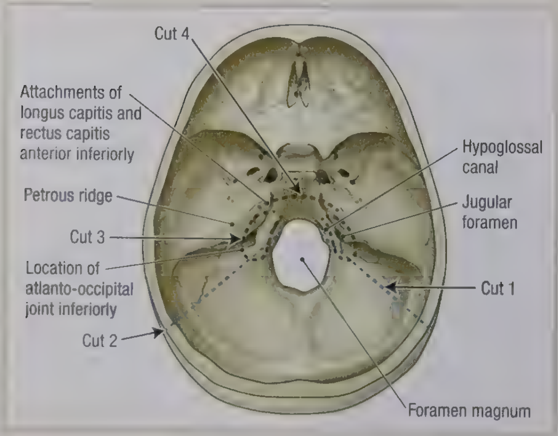

Cut 4
Attachments of longus capitis and rectus capitis anterior inferiorly
Petrous ridge
Cut 3
Location of atlanto-occipital joint inferiorly
Cut 2
Hypoglossal canal
Jugular foramen
Cut 1
Foramen magnum

FIGURE 7.63 ■ Cuts for head disarticulation. Superior view.

## Prevertebral and Lateral Vertebral Regions

ATLAS 8.23; VIDEO 7.14.3

1. Refer to FIGURE 7.64.
2. Identify the **prevertebral fascia** on the anterior surface of the cervical vertebral column.
3. Observe that the prevertebral fascia covers the prevertebral muscles (**longus colli** and **longus capitis muscles**) and the lateral vertebral muscles (**anterior**, **middle**, and **posterior scalene muscles**).
4. On the left side of the cervical vertebral column, identify the **superior**, **middle**, and **inferior cervical sympathetic ganglia** of the **sympathetic trunk**. *Note that frequently, the inferior cervical ganglion is fused with the first thoracic ganglion to form the cervicothoracic (stellate) ganglion.*

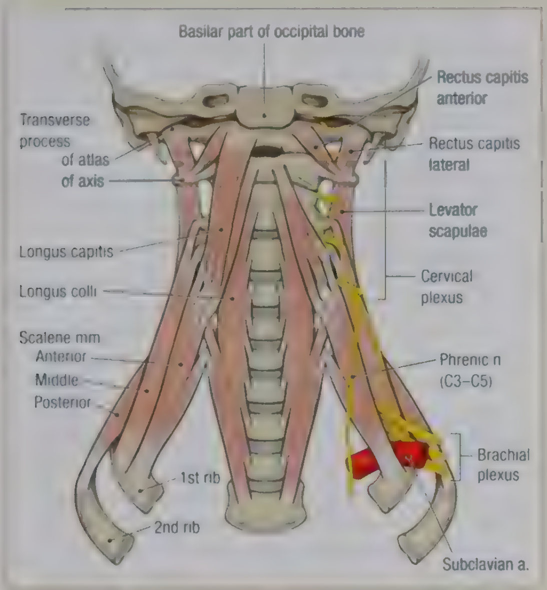


FIGURE 7.64 ● Prevertebral muscles. Anterior view.

5. Identify the **gray rami communicantes** that connect the sympathetic ganglia with the anterior rami of cervical spinal nerves.
6. Identify the roots of the brachial plexus made by the anterior rami of spinal nerves C5–C8, emerging between the anterior and middle scalene muscles.
7. At the base of the neck, follow the right and left vertebral arteries into the transverse foramina of vertebra C6, noting that as the vertebral artery ascends within the neck, it is well protected within the transverse foramina.
8. Superiorly, at the cut edge of the C1 vertebra, identify where the vertebral artery emerges from the transverse foramen of the atlas (C1). Recall that the right and left vertebral arteries ascend into the skull through foramen magnum prior to forming the basilar artery.
9. At the base of the skull, make an effort to identify the **rectus capitis anterior** and **lateral muscles.** *Note that during the disarticulation of the head, the rectus capitis anterior and lateral muscles may have been damaged.*

## Dissection Follow-up

1. Use a skull to review the anatomy of the occipital bone.
2. Review the structures that pass through the foramen magnum, hypoglossal canal, and jugular foramen.
3. Review the course of the sympathetic trunk from the upper thorax to the base of the skull.
4. Review the origin and relationships of the roots of the brachial plexus to the scalenes.
5. Return the disarticulated head and attached structures of the neck back to anatomical position.

# PHARYNX

## Dissection Overview

The pharynx extends from the base of the skull to the inferior border of the cricoid cartilage (vertebral level C6) where it is continuous with the esophagus. The pharynx can be subdivided from superior to inferior as the nasopharynx, oropharynx, and laryngopharynx. The nasopharynx communicates with the nasal cavity and serves as the primary pathway for air during respiration. The oropharynx receives air from the nasopharynx and food, liquids, and air from the oral cavity playing a key role in swallowing. The laryngopharynx is the point of separation for ingested food and liquids into the posteriorly located esophagus and for air into the larynx anteriorly.

The pharyngeal wall consists of three layers. The outermost layer is composed of buccopharyngeal fascia, the adventitia of the pharynx, which is continuous with the connective tissue covering the buccinator muscle. The middle layer is a muscular layer composed of an outer circular part and an inner longitudinal part. The innermost layer is composed of a mucous membrane with a thick submucosa that contributes to the pharyngobasilar fascia.

The order of dissection will be as follows: The external surface of the pharynx will be dissected from the posterior direction. The pharyngeal plexus of nerves will be identified, and the borders of the pharyngeal constrictor muscles will be defined. The stylopharyngeus muscle and glossopharyngeal nerve will be identified. The contents of the carotid sheath will be examined, and CN IX, X, XI, and XII will be followed from the base of the skull to their regions of distribution. The sympathetic trunk will be studied.

## Dissection Instructions

### Muscles of the Pharyngeal Wall

ATLAS 8.27, 8.28; VIDEO 7.15.1

***Dissection Note:*** For the following dissection sequence, make an effort to preserve the surrounding neurovascular structures and simply identify the muscles at this time.

1. Refer to FIGURE 7.65.
2. With the cadaver in the supine position, lift the head and place the chin on the thorax. The pharynx should now be exposed along its posterior surface.
3. Palpate the tips of the **greater horns of the hyoid bone** and the **posterior aspect of the thyroid cartilage**.
4. On the posterior aspect of the muscular pharynx, identify the **buccopharyngeal fascia**. As each muscle is identified in the following dissection steps, remove the **buccopharyngeal fascia** from the posterior surface of the muscle.
5. In the midline of the posterior pharynx, identify the **pharyngeal raphe**, the posterior attachment of the three pharyngeal constrictor muscles to each other.
6. Beginning inferiorly on the posterior aspect of the pharynx at the height of the thyroid cartilage, identify the **inferior pharyngeal constrictor muscle**.
7. The inferior pharyngeal constrictor can be subdivided into the more superiorly located **thyropharyngeus muscle** and the more inferiorly located **cricopharyngeus muscle** based on the anterior attachments of the fibers.
8. Observe that the fibers of the **cricopharyngeus muscle** are continuous with the circular muscle fibers of the esophagus.
9. Identify the **middle pharyngeal constrictor muscle** at the height of the greater horn of the hyoid bone and observe that it lies deep to the inferior pharyngeal constrictor muscle.
10. Superior to the middle pharyngeal constrictor muscle, identify the **superior pharyngeal constrictor muscle**.
11. Observe that the inferior part of the superior pharyngeal constrictor muscle lies deep to the middle pharyngeal constrictor muscle.
12. Clear the buccopharyngeal fascia from the posterior surfaces of all the pharyngeal constrictors near the midline.
13. Review the attachments and actions of the pharyngeal constrictor muscles (see **TABLE 7.7**).
14. Use blunt dissection to define the superior border of the superior pharyngeal constrictor muscle and identify the **pharyngobasilar fascia**, the dense connective tissue membrane that attaches the superior edge of the superior constrictor to the base of the skull.
15. Identify the **stylopharyngeus muscle** located on the lateral aspects of the pharynx approximately

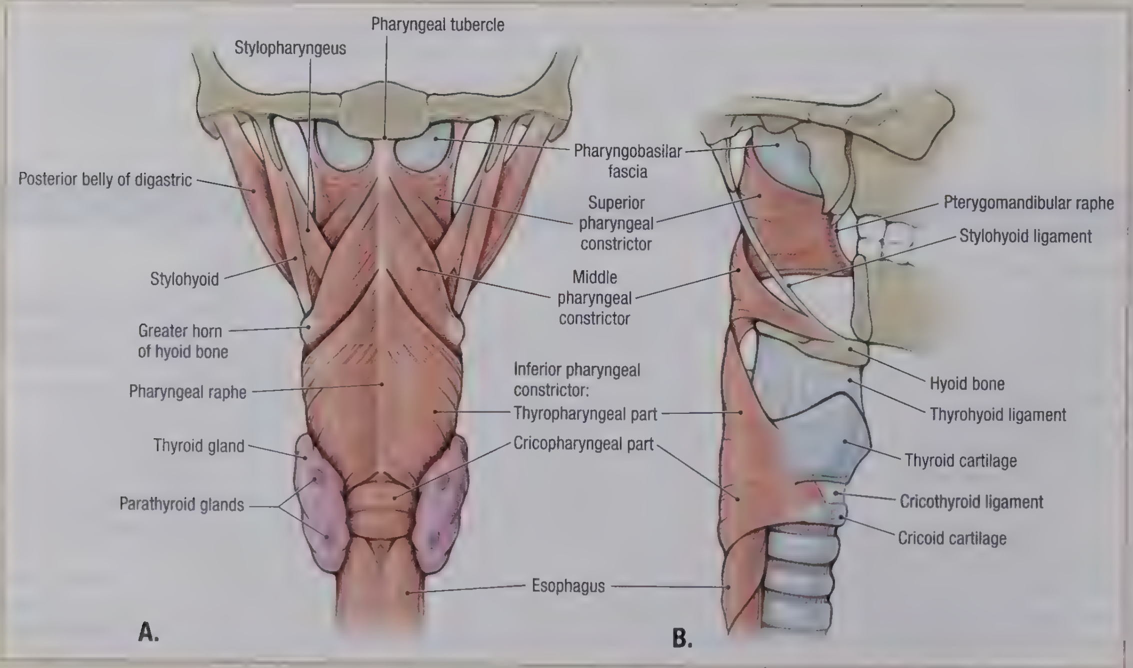

Pharyngeal tubercle
Stylopharyngeus
Posterior belly of digastric
Pharyngobasilar fascia
Superior pharyngeal constrictor
Stylohyoid
Middle pharyngeal constrictor
Greater horn of hyoid bone
Inferior pharyngeal constrictor:
Pharyngeal raphe
Thyropharyngeal part
Thyroid gland
Cricopharyngeal part
Parathyroid glands
Esophagus
A.
Pterygomandibular raphe
Stylohyoid ligament
Hyoid bone
Thyrohyoid ligament
Thyroid cartilage
Cricothyroid ligament
Cricoid cartilage
B.

FIGURE 7.65 ■ Muscles of the pharynx. **A.** Posterior view. **B.** Right lateral view.

one finger's width above the greater horn of the hyoid bone.

16. Follow the stylopharyngeus muscle superiorly and palpate its attachment to the medial surface of the styloid process and inferiorly to the point where it pierces the pharynx. Observe that the stylopharyngeus muscle enters the pharyngeal wall by passing between the superior and middle pharyngeal constrictor muscles.
17. Review the attachments and actions the stylopharyngeus muscle (see **TABLE 7.7**).

## Nerves of the Pharynx

ATLAS 8.27B, 8.28B; VIDEO 7.15.2

1. Refer to FIGURE 7.66.
2. Use blunt dissection to clean the posterior and lateral surfaces of the stylopharyngeus muscle and identify the **glossopharyngeal nerve (CN IX)**. Observe that the glossopharyngeal nerve crosses the posterior and lateral surfaces of the stylopharyngeus muscle to enter the pharynx.
3. Identify the **pharyngeal plexus of nerves** located on the posterolateral aspect of the pharynx.

   *Note that the pharyngeal plexus receives branches from the glossopharyngeal nerve (sensory to the pharyngeal mucosa), vagus nerve (motor to the pharyngeal constrictor muscles), and the superior cervical sympathetic ganglion (vasomotor).*
4. Identify the **contents of the carotid sheath** from the posterior view.
5. Follow the internal carotid artery superiorly as far as possible and observe that it lies medial to the internal jugular vein.
6. Identify the **glossopharyngeal nerve (CN IX), vagus nerve (CN X),** and **accessory nerve (CN XI)** where they exit the jugular foramen medial to the internal jugular vein.
7. Follow the **glossopharyngeal nerve (CN IX)** inferiorly and observe that it passes between the internal and external carotid arteries as it approaches the stylopharyngeus muscle.
8. Follow the **vagus nerve** inferiorly to the thorax and observe that it lies posterior to the internal carotid artery and internal jugular vein in the carotid sheath.
9. Identify the **superior laryngeal nerve** arising from the vagus nerve about 2.5 cm inferior to the base

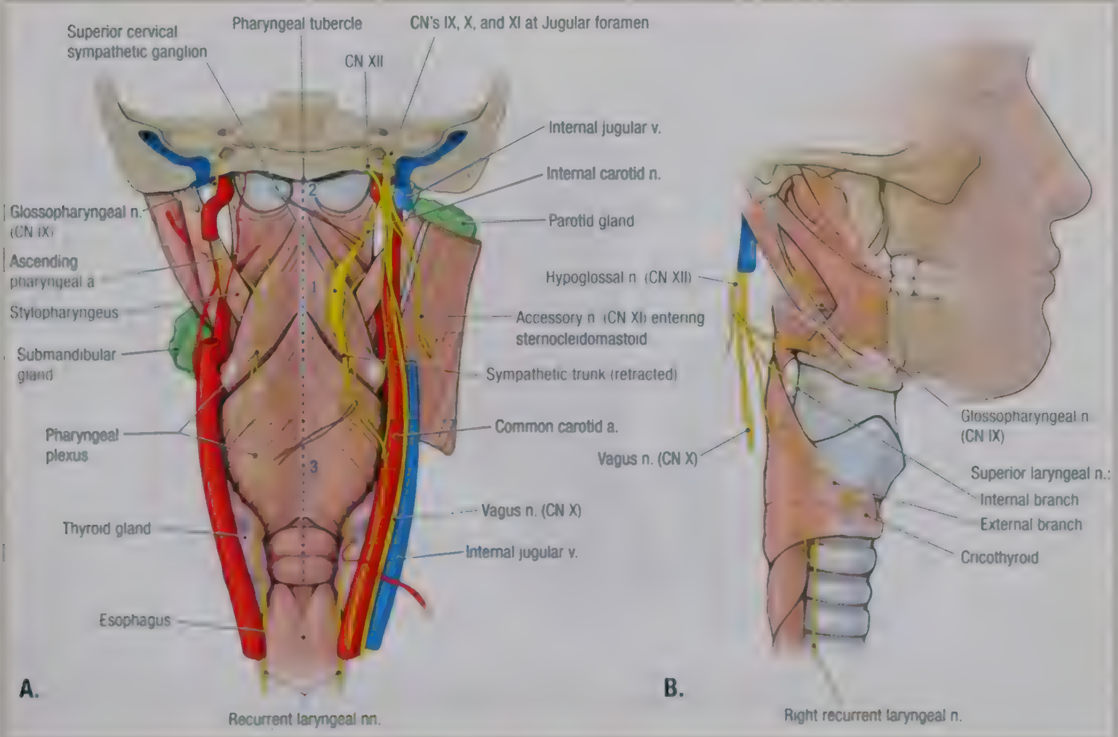

Superior cervical sympathetic ganglion
Pharyngeal tubercle
CN's IX, X, and XI at Jugular foramen
CN XII
Internal jugular v.
Internal carotid n.
Glossopharyngeal n. (CN IX)
Parotid gland
Ascending pharyngeal a
Hypoglossal n (CN XII)
Stylopharyngeus
Accessory n (CN XI) entering sternocleidomastoid
Submandibular gland
Sympathetic trunk (retracted)
Pharyngeal plexus
Common carotid a.
Vagus n. (CN X)
Thyroid gland
Vagus n. (CN X)
Internal jugular v.
Esophagus
A.
Recurrent laryngeal nn.
1
2
3
Glossopharyngeal n (CN IX)
Superior laryngeal n.:
Internal branch
External branch
Cricothyroid
B.
Right recurrent laryngeal n.

FIGURE 7.66 ■ Nerves and vessels of the pharyngeal wall. **A.** Posterior view. **B.** Right lateral view.

of the skull. Trace the branches of the superior laryngeal nerve to the larynx.

10. Identify the **pharyngeal branch of the vagus nerve** arising near the base of the skull. Follow the pharyngeal branch to the pharyngeal plexus.
11. Identify the **accessory nerve (CN XI)**, which usually passes between the internal jugular vein and the internal carotid artery to reach the deep surface of the SCM.
12. Identify the **hypoglossal nerve (CN XII)** in the submandibular triangle and follow it posteriorly and superiorly as far as the base of the skull. Observe that the hypoglossal nerve passes lateral to the internal and external carotid arteries but medial to the internal jugular vein.
13. On the right side of the cadaver, verify that the **superior cervical sympathetic ganglion** and the **sympathetic trunk** are posterior and medial to the carotid sheath.
14. Use a scalpel to make a small incision through the posterior wall of the pharynx in the midline at the approximate level of the oral cavity (**Cut 1**).
15. Use scissors to extend the incision superiorly through the pharyngeal raphe up to the pharyngeal tubercle at the base of the skull (**Cut 2**) and inferiorly down through the inferior pharyngeal constrictor to a point just superior to the esophagus (**Cut 3**).

## Opening the Pharynx

ATLAS 8.29A, 8.34A; VIDEO 7.15.3

1. Refer to FIGURE 7.67.
2. Spread the cut edges of the pharynx and observe that the lumen of the pharynx communicates anteriorly with three cavities: nasal cavity, oral cavity, and larynx.
3. Identify the parts of the pharynx: **nasopharynx**, **oropharynx**, and **laryngopharynx**.
4. From superior to inferior, identify the **posterior nasal apertures** on either side of the **nasal septum**, the **uvula and soft palate**, the **base of the tongue**, the **epiglottis** and **epiglottic valleculae**, and the **laryngeal inlet**.

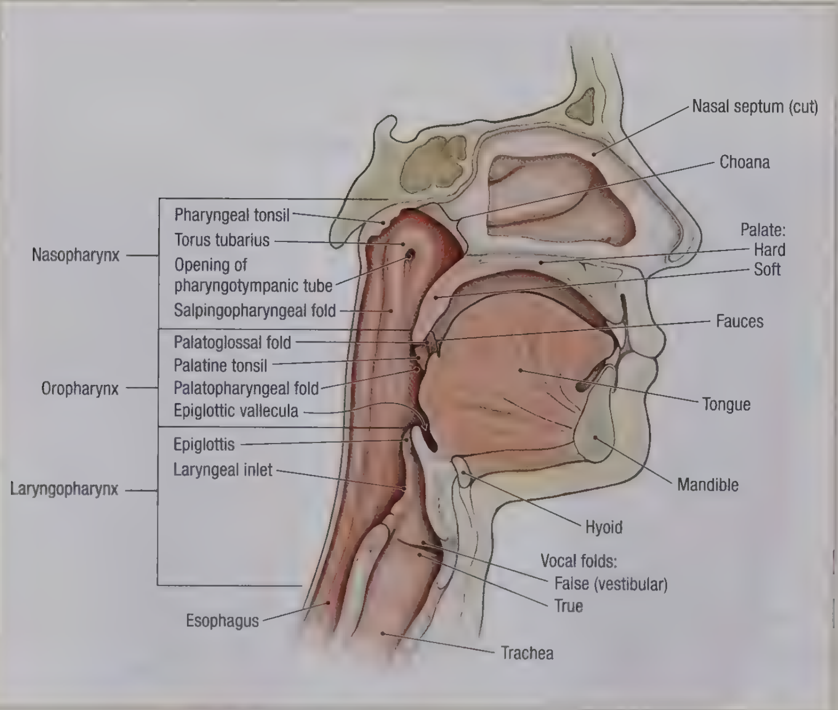

Nasal septum (cut)
Choana
Palate:
Hard
Soft
Fauces
Tongue
Mandible
Hyoid
Vocal folds:
False (vestibular)
True
Trachea
Esophagus
Nasopharynx
Pharyngeal tonsil
Torus tubarius
Opening of pharyngotympanic tube
Salpingopharyngeal fold
Oropharynx
Palatoglossal fold
Palatine tonsil
Palatopharyngeal fold
Epiglottic vallecula
Laryngopharynx
Epiglottis
Laryngeal inlet

FIGURE 7.67 ■ Midsagittal section of the pharynx. Medial view.

## Bisection of the Head

ATLAS 7.24A, 7.71, 7.73; VIDEO 7.15.4

***Dissection Note:*** A sagittal cut must be made through the skull very close to the median plane. The objective during the head bisection is to keep the nasal septum intact while cutting as close to the midline as possible. Examine each nasal cavity and decide on which side of the nasal septum the saw cut should be made in order to avoid cutting the septum.

1. Refer to FIGURE 7.68.
2. Begin the bisection of the head on the posterior aspect of the pharynx by using a scalpel to divide the uvula and the soft palate along the median plane.
3. Turn the head and use a scalpel to cut through the upper lip and the cartilages of the external nose on one side of the nasal septum, just off the midline (**Cut 1**).
4. Align a saw just lateral to the crista galli in line with your intended cut lateral to the septum so that as you cut through the skull from superior to inferior, you preserve the crista galli.
5. Cut inferiorly through the frontal and nasal bones until you reach the ethmoid bone in the floor of the anterior cranial fossa (**Cut 2**).
6. Once past the nasal septum, aim to cut through the midline of structures as much as possible.
7. Continue the midline cut through the sphenoid bone in the middle cranial fossa and into the basilar part of the occipital bone in the posterior cranial fossa (**Cut 3**).

***Dissection Note:*** Take a moment to study the oral cavity of the cadaver to look for partial or full dentures as some of the cadavers may have false teeth, which may make cuts through the palate difficult if not removed.

8. Cut through the hard palate stopping when the saw is free of the bone and rests in the oral cavity. Do not cut the tongue or mandible at this time.
9. The two superior halves of the head should separate from each other and expose the superior aspect of the tongue.

## Internal Aspect of the Pharynx

ATLAS 8.29, 8.32; VIDEO 7.15.5

1. Refer back to FIGURE 7.67.
2. In the bisected head, observe that the **nasopharynx** lies posterior to the nose and superior to the soft palate.
3. Identify the **posterior nasal aperture (choana)**, the transition region from the nasal cavity to the nasopharynx. Observe that the left and right choanae are separated by the posterior aspect of the nasal septum.
4. On the lateral wall of the nasopharynx, identify the **opening of the pharyngotympanic tube (auditory tube, eustachian tube)**.
5. Superior to the opening of the pharyngotympanic tube, identify the **torus tubarius**, the cartilage of the pharyngotympanic tube covered by mucosa.
6. Extending posteroinferiorly from the torus tubarius, identify the **salpingopharyngeal fold**. *Note that the salpingopharyngeal fold is the mucosal fold overlying the salpingopharyngeus muscle.*
7. Superior and posterior to the torus tubarius, identify the **pharyngeal recess**. The **pharyngeal tonsil (adenoid)** is located in the mucous membrane above the pharyngeal recess.

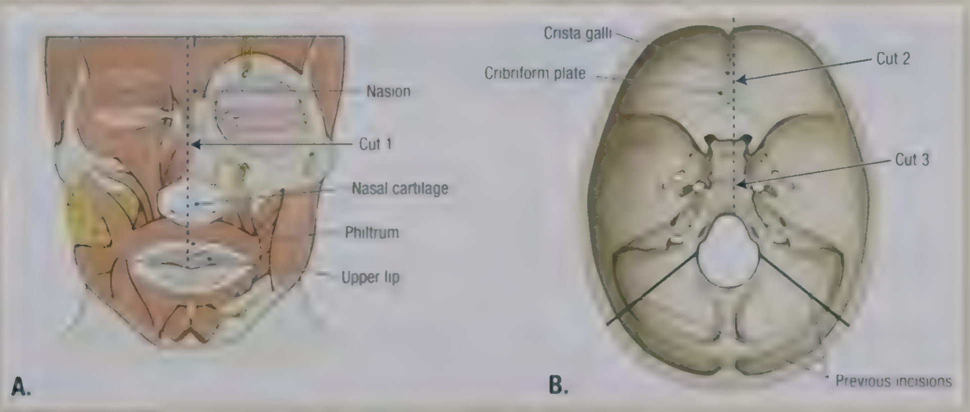


FIGURE 7.68 ■ A. Cuts through the face for head bisection. Anterior view. B. Skeletal cuts for head bisection. Superior view.

8. Observe that the **oropharynx** lies posterior to the oral cavity and is bounded superiorly by the soft palate and inferiorly at the level of the epiglottis.
9. In the oropharynx, identify the **palatoglossal folds**, which form a dividing line between the oral cavity and the oropharynx otherwise known as the **fauces**.
10. Identify the **palatopharyngeal folds** posterior to the palatoglossal folds descending along the lateral wall of the oropharynx.
11. Identify the location of the **palatine tonsil** between each palatoglossal fold and palatopharyngeal fold.
12. Identify the **laryngopharynx** posterior to the larynx extending from the hyoid bone to the lower border of the cricoid cartilage.
13. In the midline of the laryngopharynx, identify the cut edge of the **epiglottis** superior to the **laryngeal inlet (aditus)**. Observe that the margins of the laryngeal inlet are formed laterally by the **aryepiglottic folds**, which arch posteroinferiorly from the epiglottis.
14. Gently press the tip of the probe inferolateral to the aryepiglottic fold along the path of the **piriform recess**, the space bordered medially by the **larynx**, laterally by the **thyroid cartilage**, and posteriorly by the **inferior pharyngeal constrictor muscle**.

**CLINICAL CORRELATION**

### Tonsillectomy and Adenoids

ATLAS 8.30

The tonsils are collections of lymphatic tissue around the oral and nasal cavities which assist the immune system. As the majority of lymphatic growth occurs prior to puberty, in young children palatine tonsils appear large as compared to the adult. Inflammation of the tonsils (tonsillitis) caused by strep throat or other infections, as well as sleep apnea, may require removal of the tonsil (tonsillectomy). Typically, when "tonsils" are removed, it is in reference to the palatine tonsils, although it may also be necessary to remove the pharyngeal tonsils, and care must be taken to avoid damage to the glossopharyngeal nerve (CN IX) and internal carotid artery. Adenoids are enlarged pharyngeal tonsils and may obstruct the flow of air from the nose through the nasopharynx, making mouth breathing necessary thus compounding sleep apnea and snoring.

## Dissection Follow-up

1. Review the attachments, innervation, and action of the pharyngeal constrictor muscles in **TABLE 7.7**.
2. Review the nerves contributing to the pharyngeal plexus.
3. Trace the glossopharyngeal (CN IX), vagus (CN X), accessory (CN XI), and hypoglossal (CN XII) nerves from the posterior cranial fossa to their respective areas of distribution.
4. Review the relationships of the contents of the carotid sheath.
5. Review the boundaries and contents of each part of the pharynx.
6. Return the bisected head to anatomical position.

**TABLE 7.7 | Muscles of the Pharynx**

| *Muscle* | *Anterior Attachments* | *Posterior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Superior pharyngeal constrictor | Pterygoid hamulus and pterygomandibular raphe | Pharyngeal tubercle and pharyngeal raphe | Constrict wall of pharynx during swallowing | Vagus n. (CN X) via pharyngeal plexus |
| Middle pharyngeal constrictor | Greater horn of the hyoid bone and inferior portion of the stylohyoid ligament | Pharyngeal raphe | | |
| Inferior pharyngeal constrictor | Oblique line of the thyroid cartilage and lateral surface of the cricoid cartilage | | | External branch of superior laryngeal n. |
| Stylopharyngeus | Styloid process (superior attachment) | Posterior and superior borders of thyroid cartilage with palatopharyngeus (inferior attachment) | Elevate pharynx and larynx during swallowing and speaking | Glossopharyngeal n. (CN IX) |
| Salpingopharyngeus | Cartilaginous part of the pharyngotympanic tube | Posterior border of thyroid cartilage and side of pharynx and esophagus with palatopharyngeus | | Vagus n. (CN X) via pharyngeal plexus |

Abbreviations: CN, cranial nerve; n., nerve.

# NOSE AND NASAL CAVITY

## Dissection Overview

The right and left nasal cavities are separated by the nasal septum. The nostril (naris) is the anterior entrance to the nasal cavity from the external environment. Posteriorly, each nasal cavity opens into the nasopharynx through a choana. The nasal cavity is lined by mucosa that is attached directly to bones and cartilages. The bones and cartilages give the walls of the nasal cavity their characteristic contours. The superior one-third of the nasal mucosa is olfactory in nature, and the lower two-thirds is respiratory in nature. The nasal mucosa is highly vascular and capable of engorgement.

The order of dissection will be as follows: The skeleton of the nasal cavity and nasal cartilages will be studied. The nasal septum will be examined. The features of the lateral nasal wall will be studied. The openings of the paranasal sinuses will be identified. The maxillary sinus will be examined.

## Skeletal Anatomy

### Skeleton of the Nasal Cavity

ATLAS 7.2A

Refer to a skeleton or disarticulated skull to identify the following skeletal features from an anterior view.

1. Refer to FIGURE 7.69.
2. Identify the **anterior nasal aperture** and observe that it is roughly heart shaped, with the apex of the "heart" directed superiorly toward the **nasal bones** on the bridge of the nose and the broader aspect of the "heart" centered around the **anterior nasal spine** inferiorly.
3. Follow the margin of the nasal aperture superiorly and identify the **frontal process of the maxilla** between the **nasal bone** and **lacrimal bone**.
4. Identify the bony part of the **nasal septum** approximately in the midline of the skull. Observe that the nasal septum creates a division between the right and left nasal cavities.
5. On the lateral wall of the nasal cavities, identify the paired **inferior nasal concha** curving away from the lateral walls into their respective nasal cavities.
6. Superior to the inferior nasal concha, identify the **middle nasal concha**. *Note that the middle nasal concha is part of the ethmoid bone, whereas the inferior nasal concha is an independent bone.*

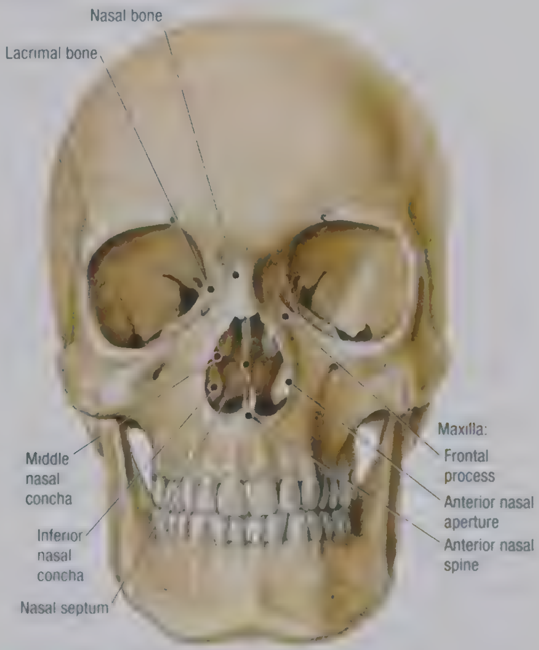


FIGURE 7.69 ● Skeleton of the nasal cavity. Anterior view.

### Lateral Nasal Wall

ATLAS 7.70A

Refer to a hemisected skull to identify the following skeletal features from a medial view.

1. Refer to FIGURE 7.70.
2. Identify the **cribriform plate of the ethmoid bone** and observe that it forms part of the floor of the anterior cranial fossa and the roof of the nasal cavities. Recall that the small apertures of the cribriform plate contain branches of the olfactory nerve (CN I).
3. Identify the **perpendicular plate of the ethmoid bone**, which forms part of the bony nasal septum in the midline, or the medial wall of the nasal cavity.
4. Identify the **superior nasal concha** and the **middle nasal concha**, which form part of the lateral wall of each nasal cavity.
5. Observe that the remainder of the lateral wall of the nasal cavity consists of portions of the **maxilla, lacrimal bone, inferior nasal concha,** and **perpendicular plate of the palatine bone**.
6. Observe that the perpendicular plate of the palatine bone lies anterior to the **medial pterygoid plate of the sphenoid bone**.

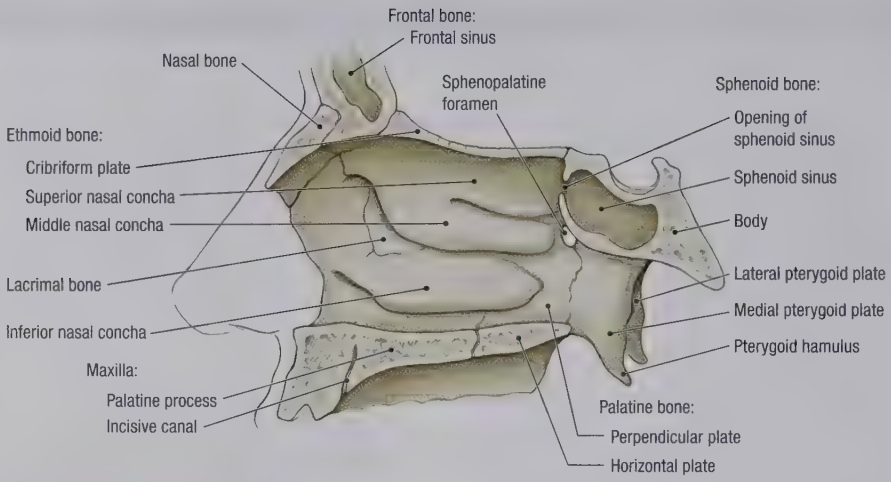

Frontal bone:
Frontal sinus
Nasal bone
Sphenopalatine foramen
Sphenoid bone:
Opening of sphenoid sinus
Sphenoid sinus
Body
Ethmoid bone:
Cribriform plate
Superior nasal concha
Middle nasal concha
Lacrimal bone
Inferior nasal concha
Maxilla:
Palatine process
Incisive canal
Lateral pterygoid plate
Medial pterygoid plate
Pterygoid hamulus
Palatine bone:
Perpendicular plate
Horizontal plate

FIGURE 7.70 ■ Skeleton of the lateral wall of the right nasal cavity. Medial view.

7. Pass a pipe cleaner or the tip of a probe gently through the **sphenopalatine foramen** and observe that this opening connects the nasal cavity with the pterygopalatine fossa.
8. In the sagittal cut, identify the **sphenoidal sinus** in the **body of the sphenoid** and observe that it is connected to the nasal cavity via the **opening of the sphenoidal sinus**.
9. Identify the **incisive canal** within the **palatine process of the maxilla**.
10. Observe that the **palatine process of the maxilla** forms the anterior aspect of the floor of the nasal cavity and hard palate, whereas the **horizontal plate of the palatine bone** forms the posterior aspect of the floor of the nasal cavity and hard palate.

## Surface Anatomy

The surface anatomy of the external nose may be studied on a living subject or on a cadaver. On the cadaver, note that fixation of tissue during embalming may make it difficult to distinguish bone from well-preserved soft tissues in some specimens.

### *External Nose*

ATLAS 7.69A, 7.69B; VIDEO 7.16.1

1. Refer to FIGURE 7.71.
2. On the cadaver, palpate the **nasal bones** and the **lateral nasal cartilages**. Observe that the lateral nasal cartilages give shape to the bridge of the nose.
3. Identify the **septal cartilage** that separates the right and left nasal cavities and forms the anterior part of the nasal septum. *Note that the lateral nasal cartilages are an extension of the septal cartilage.*
4. Lateral to the septal cartilage, palpate the **alar cartilages**, the cartilages that give shape to the medial side of the **nostril (naris)**.
5. On the cadaver, observe that the bones and cartilages of the nasal cavity are obscured by the mucosa that covers them. *Note that the vessels and nerves of the nasal cavity are contained within this mucosa.*

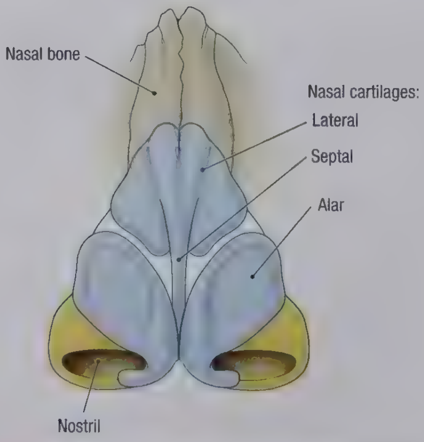

Nasal bone
Nasal cartilages:
Lateral
Septal
Alar
Nostril

FIGURE 7.71 ■ Cartilages of the external nose. Anterior view.

## Dissection Instructions

### Nasal Septum

ATLAS 7.70B, 7.71B, 7.72B; VIDEO 7.16.2

1. Refer to FIGURE 7.72.
2. On the cadaver, examine the half of the head containing the intact **nasal septum**.
3. In the mucosa of the nasal septum, use blunt dissection to peel away the nasal mucosa and then identify the **nasopalatine nerve** and the **sphenopalatine artery**.
4. Observe that the nasopalatine nerve and the sphenopalatine artery pass diagonally down the nasal septum from the sphenopalatine foramen to the incisive canal. *Note that in addition to the nasal septum, the nasopalatine nerve and sphenopalatine artery supply a portion of the oral mucosa that covers the hard palate.*
5. Identify the **olfactory area**, the mucosa near the cribriform plate in the roof and superior aspect of the lateral wall of the nasal cavity.
6. Refer to FIGURE 7.73.
7. Strip the mucosa off the visible side of the nasal septum and identify the **perpendicular plate of the ethmoid bone** extending inferiorly from the ethmoid bone in line with the crista galli.
8. Identify the **vomer** in the posterior inferior aspect of the nasal septum. Observe that the vomer subdivides the right and left **choanae** posteriorly.
9. Identify the **septal cartilage** anterior to the vomer and perpendicular plate of the ethmoid. Observe that the septal cartilage subdivides the **nostrils** anteriorly.

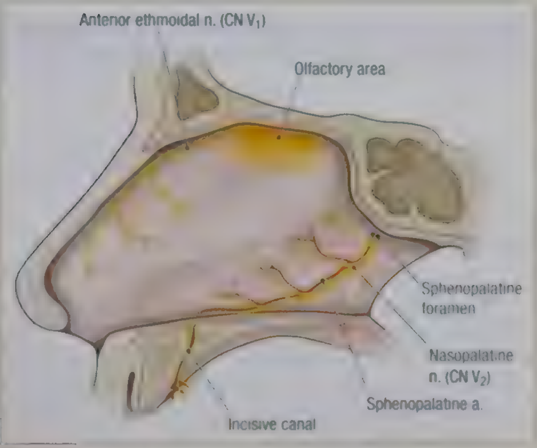

Anterior ethmoidal n. (CN V$_1$)
Olfactory area
Sphenopalatine foramen
Nasopalatine n. (CN V$_2$)
Sphenopalatine a.
Incisive canal

FIGURE 7.72 ■ Innervation and arterial supply to the mucosa of the nasal septum. Lateral view.

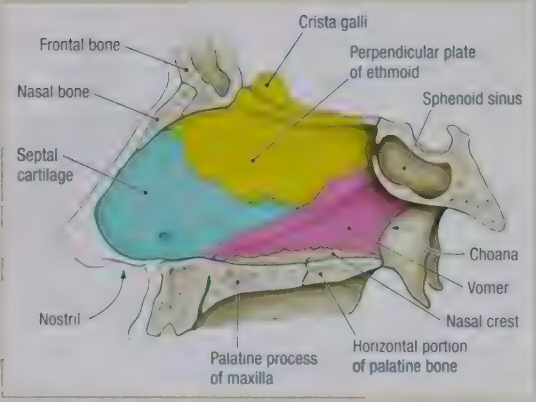

Crista galli
Frontal bone
Perpendicular plate of ethmoid
Nasal bone
Sphenoid sinus
Septal cartilage
Choana
Vomer
Nostril
Nasal crest
Palatine process of maxilla
Horizontal portion of palatine bone

FIGURE 7.73 ■ Nasal septum. Left lateral view.

10. Identify the **nasal crest** in the midline along the superior surface of the **palatine process of the maxilla** and at the junction of the right and left **horizontal plates of the palatine bones**.

### Lateral Wall of the Nasal Cavity

ATLAS 7.71A, 7.73, 7.74A, 7.77A; VIDEO 7.16.3

1. Refer to FIGURE 7.74.
2. On the cadaver, examine the half of the head that does not contain the **nasal septum**.
3. Inspect the lateral wall of the nasal cavity and identify the **superior nasal concha**.

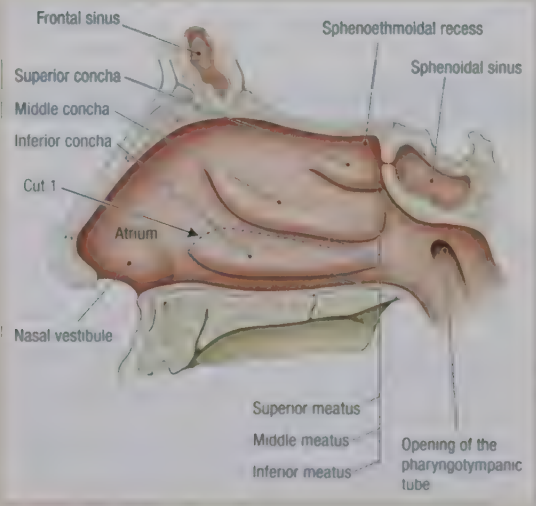

Frontal sinus
Sphenoethmoidal recess
Superior concha
Sphenoidal sinus
Middle concha
Inferior concha
Cut 1
Atrium
Nasal vestibule
Superior meatus
Middle meatus
Inferior meatus
Opening of the pharyngotympanic tube

FIGURE 7.74 ■ Nasal conchae and meatuses of the right nasal cavity. Medial view.

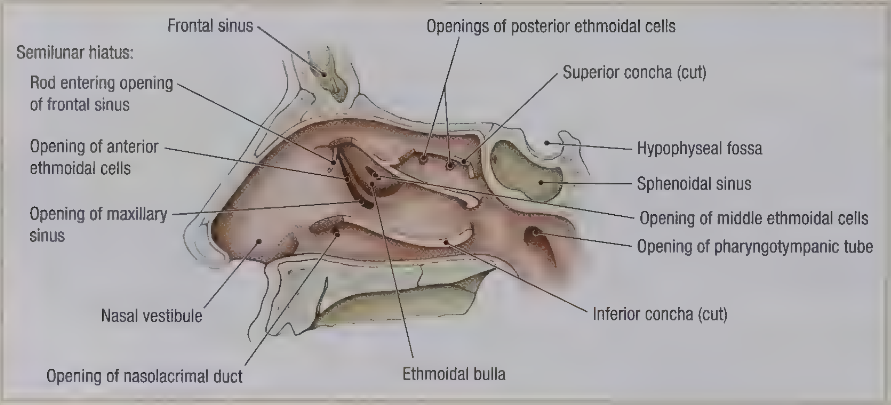

Frontal sinus
Semilunar hiatus:
Rod entering opening of frontal sinus
Opening of anterior ethmoidal cells
Opening of maxillary sinus
Nasal vestibule
Opening of nasolacrimal duct
Ethmoidal bulla
Openings of posterior ethmoidal cells
Superior concha (cut)
Hypophyseal fossa
Sphenoidal sinus
Opening of middle ethmoidal cells
Opening of pharyngotympanic tube
Inferior concha (cut)

FIGURE 7.75 ● Openings in the lateral wall of the right nasal cavity. Medial view.

4. Superior and posterior to the superior nasal concha, identify the **sphenoethmoidal recess.** Inferior to the superior nasal concha, place the tip of the probe into the space of the **superior meatus.**
5. Identify the **middle concha** curving superior to the **middle meatus** and the **inferior concha** curving superior to the **inferior meatus**.
6. Identify the **vestibule**, the area superior to the nostril and anterior to the inferior meatus and the **atrium**, the area superior to the vestibule and anterior to the middle meatus.
7. Use scissors to remove the **inferior concha (Cut 1)**.
8. Refer to FIGURE 7.75.
9. Inferior to the cut edge of the inferior concha, identify the opening of the **nasolacrimal duct**.
10. Elevate the **middle concha** until you hear the bone break and the concha can be reflected superiorly. Leave the middle concha attached by the mucosa.
11. In the middle meatus, identify a curved slit, the **semilunar hiatus (hiatus semilunaris)**.
12. Posterior to the curvature of the semilunar hiatus, identify the **ethmoidal bulla (bulla ethmoidalis)**, which bulges into the nasal cavity.
13. Within the semilunar hiatus, identify three openings. From anterior to posterior, they are the **opening of the frontal sinus**, the **opening of the anterior ethmoidal cells**, and the **opening of the maxillary sinus**.

***Dissection Note:*** A piece of wire may be passed through the openings to verify the orientation and continuity of each space with the nasal cavity.

14. On the summit of the ethmoidal bulla, identify the **opening of the middle ethmoidal cells**.
15. Identify the **opening of the posterior ethmoidal cells** in the superior meatus.
16. Identify the **opening of the sphenoidal sinus** in the sphenoethmoidal recess.

CLINICAL CORRELATION

### Pituitary Tumor Removal

ATLAS 7.7B, 7.73

The pituitary gland is often referred to as the "master gland" due to the high number of hormones it releases. Pituitary tumors may lead to large hormonal imbalances in the body, vision problems, headaches, or a variety of other symptoms. Depending on the size and severity of the tumor, it may be treated by medications or radiation, or it may need to be surgically removed. As the sphenoid sinus lies directly inferior to the hypophyseal fossa containing the pituitary gland, relatively easy surgical access is available in a transsphenoidal approach. Transsphenoidal surgery may be done through the nostrils and nasopharynx, an endonasal approach, or by passing through the upper lip to open a path between the hard palate and the nasal cavity in a sublabial approach.

17. Examine the **sphenoid sinus**. Observe that the sphenoid sinus is a paired structure lined by mucosa that is continuous with the mucosa of the nasal cavity.
18. Refer to FIGURE 7.76.
19. From a superior perspective, observe that the **ethmoidal cells** are located between the nasal cavity and the orbit.
20. Observe that the ethmoid air cells consist of an **anterior** pair near the **frontal sinus**, a **middle** pair, and a **posterior** pair near the location of the **sphenoid sinus**. *Note that variation is common, and the individual air cells may be split or appear as clusters of smaller mucosal lined cavities.*
21. Refer back to FIGURE 7.47.

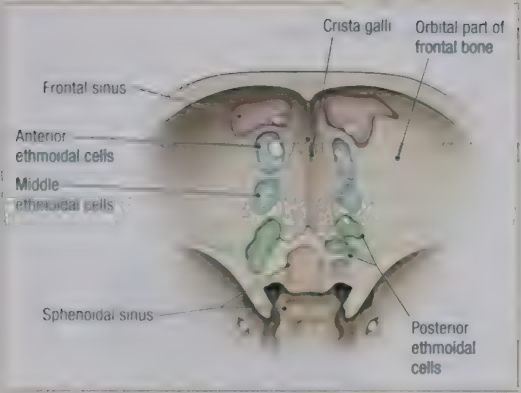


FIGURE 7.76 ■ Paranasal sinuses. Superior view.

22. In a coronal cut of the head observe that the **maxillary sinus** is approximately shaped like a three-sided pyramid. *Note that in the average adult, the maxillary sinus has a capacity of about 15 mL.*
23. Observe that the **floor of the orbit** forms the roof of the maxillary sinus and that the **opening of the maxillary sinus** is near its roof, thus the maxillary sinus drains superiorly.
24. Observe that the floor of the maxillary sinus is the alveolar process of the maxilla and that the roots of the maxillary teeth may project into the maxillary sinus. *Note that the mucosa of the maxillary sinus is innervated by the infraorbital and posterior superior alveolar nerves.*

**CLINICAL CORRELATION**

**Maxillary Sinus Infection**

ATLAS 7.77

When the head is in the upright position the maxillary sinus cannot drain which leads to an increased likeliness of infection or inflammation (sinusitis). If infections of the maxillary sinus persist, an opening may be surgically created through the inferior meatus near the floor of the maxillary sinus to promote drainage.

If the roots of maxillary teeth project into the maxillary sinus, they are covered only by mucosa. During extraction of a maxillary molar or premolar tooth, the mucosa superior to the projecting root may be torn. As a result, a fistula may form between the oral cavity and the maxillary sinus.

## Dissection Follow-up

1. Review the features of the lateral wall of the nasal cavity.
2. Review the relationship of the paranasal sinuses to the orbit, anterior cranial fossa, and nasal cavity.
3. Review the drainage point of each paranasal sinus.
4. Return any reflected tissue and the bisected head to anatomical position.

# THE PALATE AND PTERYGOPALATINE FOSSA

## Dissection Overview

The palate forms the floor of the nasal cavity and the roof of the oral cavity, thus it is covered by nasal mucosa on its superior surface and oral mucosa on its inferior surface. The palate consists of two portions: the hard palate, which forms the anterior two-thirds surrounded by the upper dentition, and the soft palate, which constitutes the posterior one-third extending into the pharynx. Numerous mucous glands (palatine glands) are present on the oral surface of the palate.

The majority of the neurovascular structures supplying the hard and soft palate originate in the face and take a long intraosseous route to reach their target. As such, the nerves and vessels must pass from the infratemporal fossa through the bones of the skull to enter the pterygopalatine fossa deep within the cheek and continue medially to the lateral aspect of the nasal cavity. From the lateral wall of the nasal cavity, the neurovascular path will either arch to the midline along the nasal septum or descend within the bone to reach their target destinations of the hard or soft palate.

The order of dissection will be as follows: The mucosal folds of the inner pharyngeal wall will be reviewed. The mucosa will be stripped from the inner surface of the pharynx, and the muscles that constitute the inner longitudinal muscle layer will be examined. Muscles that move the soft palate will then be studied. The nerves and blood vessels of the palate will be identified. The palatine canal and pterygopalatine fossa will be dissected from the medial aspect. The pterygopalatine ganglion will be identified. The nerves and vessels of the nasal cavity and palate will be summarized.

## Skeletal Anatomy

Refer to a disarticulated skull to identify the following skeletal features from an inferior view.

### Dentition

ATLAS 7.63A

1. Refer to FIGURE 7.77.
2. The teeth can be subdivided into an **upper dentition (maxillary teeth)** and a **lower dentition (mandibular teeth)**.
3. Examine the upper dentition on the inferior aspect of the **maxilla**.
4. Observe that each tooth has an individual socket demarcated by an **alveolar process** extending inferiorly from the maxillary bone.
5. Identify the two **central incisors** to either side of the midsagittal plane anteriorly and the two **lateral incisors** immediately lateral to either side.
6. Continuing laterally, identify the two **canines (cuspids)**, noting the distinct difference in shape from the incisors.
7. Identify the four **premolars (bicuspids)** posterolateral to the canines, two on each side.
8. Identify the six **molars** posterior to the premolars, three on each side and numbered from 1 to 3 as they progress further from the premolars with the third being the "wisdom tooth." *Note that often the wisdom teeth are removed to prevent overcrowding of the oral cavity.*

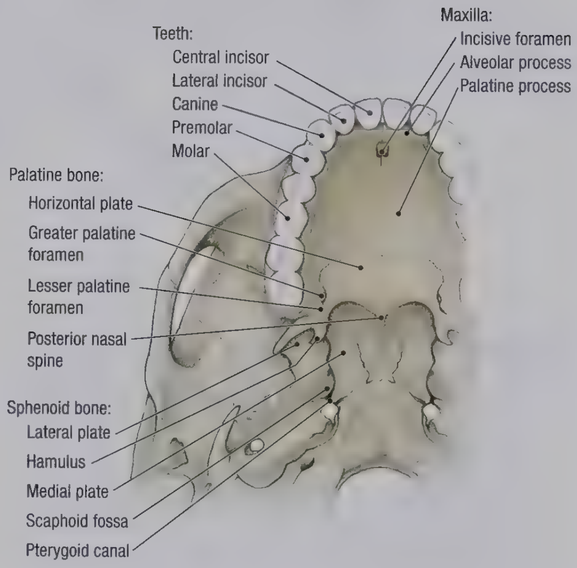


FIGURE 7.77 ● Skeleton of the palate. Inferior view.

9. Observe that in the adult there are 16 teeth on each dentition making a total of 32 teeth.
10. Identify the 16 maxillary teeth beginning with the right upper 3rd molar as number 1 and the left upper 3rd molar as number 16, with 8 and 9 being the central incisors.
11. On a disarticulated mandible, identify the 16 mandibular teeth with the left lower 3rd molar as 17 and the right lower 3rd molar as 32, with 24 and 25 being the central incisors.
12. Alternatively, the teeth may be subdivided into quadrants as upper right, lower right, upper left, and lower left. With the quadrant numbering system, the teeth in each quadrant are numbered 1 to 8 beginning with the central incisor of the quadrant being number 1, and the 3rd molar of the quadrant being number 8.

***Dissection Note:*** Each tooth has five surfaces named for its orientation. The facial surface is closest to the face and can be subdivided into labial for the incisors and canines and buccal for the premolars and molars. The lingual surface is closest to the tongue. The mesial surface is the side of the tooth closest to the midsagittal plane, with the distal surface as the side furthest from the midsagittal plane as the teeth progress laterally and posteriorly. Lastly, the incisal surface is the cutting edge of the anterior teeth, and the occlusal surface is the chewing surface for the posterior teeth.

### Hard Palate

ATLAS 7.63A

1. Refer to FIGURE 7.77.
2. Identify the **hard palate**. Observe that the **palatine processes** of the maxillae form the anterior aspect of the hard palate, whereas the **horizontal plates of the palatine bones** form the posterior aspect of the hard palate.
3. Posterior to the incisors, identify the **incisive foramen** between the palatine processes of the maxillae.
4. Between the maxilla and palatine bone, identify the larger, more anteriorly located **greater palatine foramen** and the slightly smaller, more posteriorly located **lesser palatine foramen**.
5. In the midline of the palatine bones on the posterior margin of the hard palate, identify the **posterior nasal spine** inferior to the nasal septum.
6. Identify the "hook-like" process of the **pterygoid hamulus** on the inferior aspect of the medial plate of the pterygoid process of the **sphenoid bone**.
7. Observe that the medial plate of the pterygoid process is separated from the **lateral plate of the pterygoid process** by the depression of the **pterygoid fossa**.

### *Pterygopalatine Fossa*

ATLAS 7.48D, 7.78A

1. Refer to FIGURE 7.78.
2. Identify the **inferior orbital fissure** between the maxilla and greater wing of the sphenoid.
3. Identify the **pterygomaxillary fissure** between the lateral plate of the pterygoid process and the maxilla.
4. Pass a pipe cleaner through the pterygomaxillary fissure and into the small cavity of the **pterygopalatine fossa**.
5. On the medial wall of the pterygopalatine fossa, identify the small opening of the **sphenopalatine foramen**.
6. Pass a pipe cleaner through the sphenopalatine foramen and confirm that this opening connects the nasal cavity with the pterygopalatine fossa.
7. From an inferior view, identify the small opening of the **pterygoid canal** in the anterior margin of the **foramen lacerum**. Pass a thin wire through the pterygoid canal and observe that it connects to the pterygopalatine fossa.

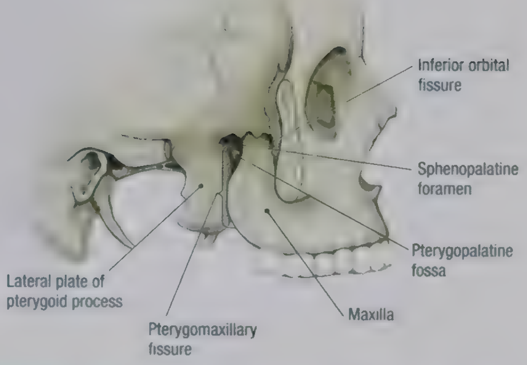

Inferior orbital fissure
Sphenopalatine foramen
Pterygopalatine fossa
Lateral plate of pterygoid process
Maxilla
Pterygomaxillary fissure

FIGURE 7.78 ● Right pterygopalatine and infratemporal fossae. Lateral view.

## Dissection Instructions

### Soft Palate

ATLAS 7.63B, 7.63C, 7.63D, 8.32; VIDEO 7.17.1

1. Refer to FIGURE 7.79.
2. Examine the edge of the **soft palate** where it is cut in the sagittal plane and observe that muscles attach to its posterior two-thirds providing the associated mobility of the structure.
3. Observe that the thickness of the soft palate is partly due to the presence of palatine glands and that the strength of the soft palate is primarily due to the **palatine aponeurosis**.
4. On the inner pharyngeal wall, identify the **opening of the pharyngotympanic tube** inferior to the mucous-lined cartilage of the **torus tubarius**.
5. Observe that the **pharyngotympanic (auditory, eustachian) tube** connects the nasopharynx to the tympanic cavity. *Note that the part of the pharyngotympanic tube that is closest to the pharynx is cartilaginous (approximately two-thirds of its length) and the part that is closest to the middle ear passes through the temporal bone.*
6. Within the opening of the pharyngotympanic tube, identify the **torus levatorius**, the "bump" of mucosa overlying the **levator veli palatini** on the floor of the **pharyngotympanic tube**.
7. Identify the **salpingopalatine fold** arising from the anterior aspect of the torus tubarius and coursing to the soft palate.
8. Identify the **salpingopharyngeal fold** arising from the posterior aspect of the torus tubarius and coursing inferiorly into the pharynx.
9. Identify the **palatoglossal fold (anterior fauces)**, arching from the palate to the tongue, and the **palatopharyngeal fold (posterior fauces)**, arching from the palate to the pharynx.
10. Refer to FIGURE 7.80.
11. Use blunt dissection to remove the mucosa from the palatoglossal fold and identify the **palatoglossus muscle**, which lies within the fold.
12. Remove the mucosa from the palatopharyngeal fold and identify the **palatopharyngeus muscle**, which lies within the fold.

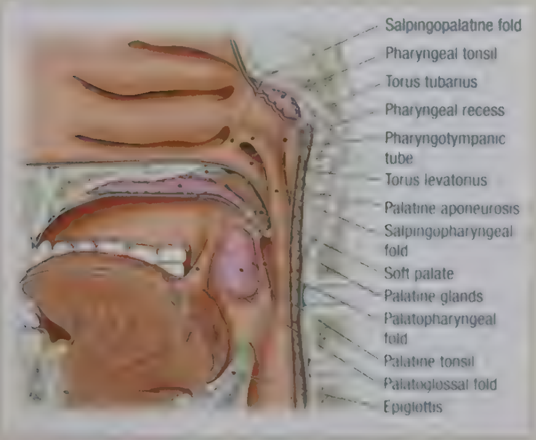

Salpingopalatine fold
Pharyngeal tonsil
Torus tubarius
Pharyngeal recess
Pharyngotympanic tube
Torus levatorius
Palatine aponeurosis
Salpingopharyngeal fold
Soft palate
Palatine glands
Palatopharyngeal fold
Palatine tonsil
Palatoglossal fold
Epiglottis

FIGURE 7.79 ● Mucosal folds in the right pharynx. Medial view.

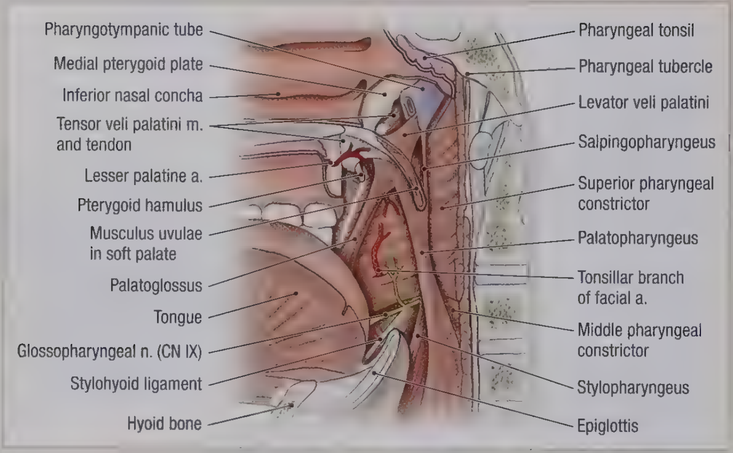

Pharyngotympanic tube
Medial pterygoid plate
Inferior nasal concha
Tensor veli palatini m. and tendon
Lesser palatine a.
Pterygoid hamulus
Musculus uvulae in soft palate
Palatoglossus
Tongue
Glossopharyngeal n. (CN IX)
Stylohyoid ligament
Hyoid bone
Pharyngeal tonsil
Pharyngeal tubercle
Levator veli palatini
Salpingopharyngeus
Superior pharyngeal constrictor
Palatopharyngeus
Tonsillar branch of facial a.
Middle pharyngeal constrictor
Stylopharyngeus
Epiglottis

FIGURE 7.80 ● Muscles of the right pharyngeal wall. Medial view.

13. Remove the mucosa from the salpingopharyngeal fold and identify the **salpingopharyngeus muscle**, which lies within the fold. *Note that the palatopharyngeus and salpingopharyngeus muscles blend together and contribute to the inner longitudinal muscle layer of the pharynx.*
14. Review the attachments, actions, and innervations of the palatoglossus, palatopharyngeus, and salpingopharyngeus muscles (see **TABLE 7.8**).
15. Remove the remaining mucosa from the inner surface of the nasopharynx and oropharynx.
16. Identify the **stylopharyngeus muscle**, which enters the pharynx between the **superior** and **middle pharyngeal constrictor muscles**.
17. Observe that the stylopharyngeus muscle lies anterior and parallel to the palatopharyngeus and salpingopharyngeus muscles and that all three muscles blend near their inferior ends.
18. Review the attachments and actions of the stylopharyngeus muscle (see **TABLE 7.7**).
19. Observe that the **pharyngobasilar fascia** closes the gap between the superior border of the superior pharyngeal constrictor muscle and the base of the skull. *Note that the pharyngotympanic tube and the levator veli palatini muscle pass through the gap in the pharyngobasilar fascia.*
20. Remove the mucosa from the torus levatorius and identify the **levator veli palatini muscle**. Observe that the fibers of the levator veli palatini course along the floor of the auditory tube.
21. Remove the mucosa from the medial aspect of the **medial pterygoid plate**.
22. Carefully use bone cutters to chip away portions of the medial pterygoid plate and identify the **tensor veli palatini muscle**. *Note that the belly of the tensor veli palatini muscle is located between the medial and lateral plates of the pterygoid process.*
23. Palpate the **hamulus of the medial pterygoid plate** and find the tendon of the tensor veli palatini muscle, which turns medially around the hamulus and attaches to the **palatine aponeurosis**.
24. Along the cut edge of the uvula, identify the **musculus uvulae**, which arises from the posterior nasal spine to elevate and retract the uvula. *Note that as the musculus uvulae and levator veli palatini muscles contract, the soft palate thickens centrally and closes the pharynx between the nasopharynx and oropharynx.*
25. Review the attachments and actions of the levator and tensor veli palatini muscles and the musculus uvulae (see **TABLE 7.8**).
26. Refer to **TABLE 7.8** and note that five muscles of the soft palate and pharynx are innervated by the vagus nerve (CN X) via the pharyngeal plexus: salpingopharyngeus, levator veli palatini, palatoglossus, palatopharyngeus, and musculus uvulae. *Note that the tensor veli palatini muscle is innervated by the mandibular division of the trigeminal nerve (CN $V_3$), not the vagus nerve.*
27. Use a probe to raise the mucosa on the inferior surface of the hard palate where it was cut during head bisection, and grasp it with forceps or a hemostat, and use blunt dissection to peel it from medial to lateral.
28. Detach the mucosa along the medial side of the alveolar process of the maxilla.
29. Refer to FIGURE 7.81.
30. Identify the **greater palatine artery** and **nerve** where they emerge from the **greater palatine foramen**.
31. Use blunt dissection to follow the greater palatine nerve and artery anteriorly. *Note that the nasopalatine nerve and the distal end of the sphenopalatine artery supply the mucosa over the anterior part of the hard palate.*

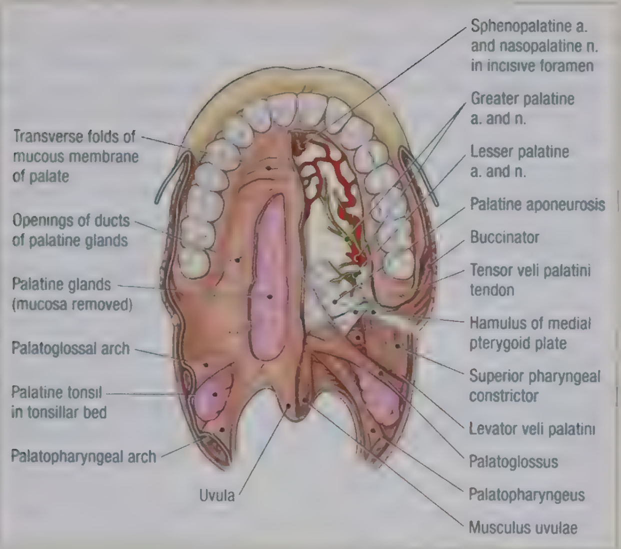

Transverse folds of mucous membrane of palate
Openings of ducts of palatine glands
Palatine glands (mucosa removed)
Palatoglossal arch
Palatine tonsil in tonsillar bed
Palatopharyngeal arch
Uvula
Sphenopalatine a. and nasopalatine n. in incisive foramen
Greater palatine a. and n.
Lesser palatine a. and n.
Palatine aponeurosis
Buccinator
Tensor veli palatini tendon
Hamulus of medial pterygoid plate
Superior pharyngeal constrictor
Levator veli palatini
Palatoglossus
Palatopharyngeus
Musculus uvulae

FIGURE 7.81 ● Mucosa and glands (*right*) and underlying muscles, nerves, and vessels (*left*) of the palate. Inferior view.

32. Posterior to the greater palatine nerve, identify the **lesser palatine artery** and **nerve**.
33. Use blunt dissection to follow the lesser palatine artery and nerve to the soft palate, which they supply.

## Tonsillar Fossa

ATLAS 7.64A, 8.31C, 8.32; VIDEO 7.17.2

1. Refer to FIGURE 7.81.
2. Identify the **palatine tonsil** in the **tonsillar fossa (bed)**. *Note that in older individuals, the palatine tonsil may be inconspicuous or may have been surgically removed.*
3. Identify the **anterior boundary** of the tonsillar bed formed by the **palatoglossal fold** and the **posterior boundary** of the tonsillar bed formed by the **palatopharyngeal fold**.
4. Observe that the **lateral boundary** of the tonsillar bed is formed by the **superior pharyngeal constrictor muscle**.
5. If the cadaver has a palatine tonsil, use blunt dissection to remove it. Section the tonsil and observe the **crypts** that extend into its surface.
6. Remove the mucosa from the tonsillar bed and identify the **glossopharyngeal nerve (CN IX)**.
7. Observe that the glossopharyngeal nerve passes between the superior and the middle pharyngeal constrictor muscles to enter the tonsillar bed. *Note that the glossopharyngeal nerve innervates the mucosa of the posterior one-third of the tongue and the posterior wall of the pharynx.*

## Palatine Canal and Pterygopalatine Fossa

ATLAS 7.50B, 7.63C, 7.72A; VIDEO 7.17.3

***Dissection Note:*** Dissection of the lateral nasal wall is quite difficult because the mucosa is firmly attached to the bone and the underlying nerves vessels are easily torn.

1. Refer to FIGURE 7.82.
2. Remove the mucosa from the posterior part of the lateral nasal wall.

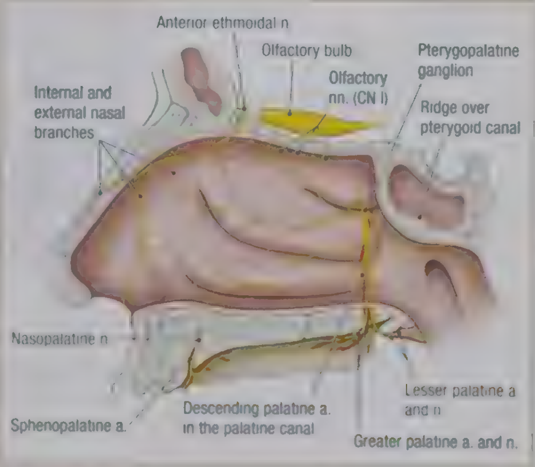

Anterior ethmoidal n
Olfactory bulb
Pterygopalatine ganglion
Olfactory nn. (CN I)
Internal and external nasal branches
Ridge over pterygoid canal
Nasopalatine n
Lesser palatine a and n
Descending palatine a. in the palatine canal
Sphenopalatine a.
Greater palatine a. and n.

FIGURE 7.82 ● Arterial supply and innervation to the mucosa of the lateral wall of the right nasal cavity. Medial view.

3. Use a probe to locate the **sphenopalatine foramen** near the posterior end of the middle nasal concha.
4. Insert a probe into the sphenopalatine foramen and direct it inferiorly toward the greater palatine foramen of the hard palate. Pull the probe medially to break the medial wall of the palatine canal.
5. Identify the **greater palatine nerve** more anteriorly and the **lesser palatine nerve** more posteriorly within the palatine canal.
6. Identify the **descending palatine artery** in the palatine canal lateral to the greater and lesser palatine nerves. Recall that the descending palatine artery is one of the terminal branches of the maxillary artery.
7. At the inferior end of the greater palatine canal, use a fine probe or needle to separate the nerves and vessels. Observe that the descending palatine artery divides to give rise to the **greater palatine artery** and the **lesser palatine artery**.
8. Place a fine probe between the greater palatine nerve and the lesser palatine nerve and slide it superiorly until it meets resistance at the inferior border of the **pterygopalatine ganglion**. *Note that the pterygopalatine ganglion stimulates secretion from the mucosa of the nasal cavity, paranasal sinuses, nasopharynx, roof of the mouth, soft palate, and the lacrimal gland.*
9. Remove the mucosa from the floor of the sphenoid sinus and look for a ridge in the floor that marks the location of the pterygoid canal.
10. Use a probe to break open the ridge and identify the **nerve of the pterygoid canal**, which enters the pterygopalatine fossa posteriorly.
11. Confirm that the nerve of the pterygoid canal ends anteriorly in the pterygopalatine ganglion. *Note that the nerve of the pterygoid canal contains presynaptic parasympathetic axons from the greater petrosal nerve and postsynaptic sympathetic axons from the deep petrosal nerve.*
12. Refer to FIGURE 7.83.
13. Turn the cadaver's head and approach it from the lateral aspect. Deep in the **infratemporal fossa,** identify the **maxillary artery**, where it courses deeply toward the pterygomaxillary fissure.
14. Near the pterygomaxillary fissure, observe that the maxillary artery gives rise to the **sphenopalatine artery**, which passes through the **pterygopalatine fossa** and then through the sphenopalatine foramen to enter the nasal cavity.
15. Branching from the maxillary artery, identify the **descending palatine artery**, which descends to enter the greater palatine canal where it was dissected from the medial side.
16. Identify the **infraorbital** artery, which passes through the inferior orbital fissure to enter the infraorbital canal and emerge on the face through the infraorbital foramen.
17. Identify the **maxillary division of the trigeminal nerve (CN $V_2$)** where it courses from the foramen rotundum to the inferior orbital fissure. Observe that the maxillary division passes through the pterygopalatine fossa and gives pterygopalatine branches that will form the greater and lesser palatine nerves.

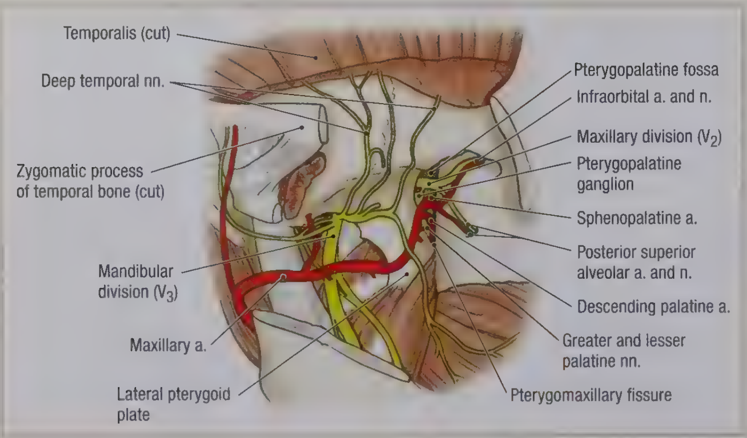

Temporalis (cut)
Deep temporal nn.
Zygomatic process of temporal bone (cut)
Mandibular division (V3)
Maxillary a.
Lateral pterygoid plate
Pterygopalatine fossa
Infraorbital a. and n.
Maxillary division (V2)
Pterygopalatine ganglion
Sphenopalatine a.
Posterior superior alveolar a. and n.
Descending palatine a.
Greater and lesser palatine nn.
Pterygomaxillary fissure

FIGURE 7.83 ■ Arteries and nerves of the pterygopalatine fossa. Lateral view.

## Dissection Follow-up

1. Review the branching pattern of the maxillary division of the trigeminal nerve using a skull and the dissected cadaver to follow its course through the various foramina of the skull.
2. Review the distribution of the following branches of the maxillary division of the trigeminal nerve: greater palatine, lesser palatine, nasopalatine, and infraorbital nerves.
3. Review the origin of the maxillary artery, its course through the infratemporal fossa, and the course of its branches.
4. Review the attachments, actions, and innervations of the muscles that move the soft palate in **TABLE 7.8**.
5. Review the attachments, actions, and innervations of the pharyngeal muscles in **TABLE 7.8**.
6. Review the pharyngeal plexus on the posterior surface of the pharynx and recall its role in innervation of the pharyngeal mucosa and the muscles of the pharynx and soft palate.
7. Review the course of the glossopharyngeal nerve from the jugular foramen to the posterior one-third of the tongue.
8. Replace any reflected tissue back to anatomical position.

**TABLE 7.8 | Muscles of the Palate and Pharynx**

| *Muscle* | *Superior Attachments* | *Inferior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Palatoglossus | Palatine aponeurosis | Lateral aspect of the tongue | Elevates tongue and depresses soft palate | Vagus n. (CN X) via pharyngeal plexus |
| Palatopharyngeus | Hard palate and palatine aponeurosis | Thyroid cartilage and pharyngeal wall | Elevate larynx during swallowing and speaking | |
| Salpingopharyngeus | Cartilage of pharyngotympanic tube | | | |
| Musculus uvulae | Posterior nasal spine (anterior attachment) and mucosa of uvula (posterior attachment) | Palatine aponeurosis | Elevates and retracts uvula | |
| Levator veli palatini | Cartilage of pharyngotympanic tube and petrous part of temporal bone | | | |
| Tensor veli palatini | Scaphoid fossa and spine of sphenoid bone | | Tenses the soft palate | Mandibular division of trigeminal n. (CN $V_3$) |

Abbreviations: CN, cranial nerve; n., nerve.

## ORAL REGION

## Dissection Overview

The oral region includes the oral cavity and its contents (teeth, gums, and tongue), the palate, and the part of the oropharynx that contains the palatine tonsils. The oral cavity can be subdivided into the oral vestibule, the area bounded by the lips and cheeks externally and the teeth and gums internally, and the oral cavity proper, the area between the alveolar arches and teeth. The largest content of the oral cavity proper is the tongue.

The order of dissection will be as follows: The superficial features of the oral region will be examined on a living person. On the cadaver, the tongue will be inspected, and the tongue and mandible will be bisected in the midline. The intrinsic muscles of the tongue will be examined. The sublingual region will be studied, and the dissection of the deep part of the submandibular gland will be completed. The extrinsic muscles of the tongue will be studied.

### Surface Anatomy

Palpate the following structures in the oral cavity on the cadaver or use a mirror and a clean finger to examine your mouth.

#### *Oral Vestibule*

ATLAS 7.60B, 7.66E

1. Refer to FIGURE 7.84.
2. Identify the region of the **oral vestibule** between the **lips** anteriorly and the **teeth** posteriorly.
3. On the **maxilla**, identify the **alveolar processes** and the **anterior surface** (above the alveolar process).

4. Elevate the **upper (superior) lip** and identify the **superior labial frenulum** in the midline attaching from the **gingivae (gums)** to the inner surface of the lip.
5. On the **mandible**, identify the **alveolar processes**.
6. Depress the **lower (inferior) lip** and identify the **inferior labial frenulum** in the midline attaching from the **gingivae (gums)** to the inner surface of the lip.

### Oral Cavity Proper

ATLAS 7.60A, 8.30

1. Refer to FIGURE 7.84.
2. Observe that the anterior and lateral borders of the **oral cavity proper** are the teeth and gingivae (gums) of the upper and lower dentition.
3. The superior border (roof) of the oral cavity is the **hard palate** anteriorly and the **soft palate** posteriorly, whereas the inferior border (floor) is the mucosa covering the **tongue** and sublingual area.
4. The posterior border of the oral cavity is defined by the opening to the **oropharynx** bounded by the right and left **palatopharyngeal folds (arches)**.
5. Identify the **palatoglossal folds (arches)** anterior to the palatopharyngeal folds. *Note that the paired palatoglossal and palatopharyngeal folds are often referred to as the anterior and posterior pillars of fauces, respectively.*
6. If present, identify the **palatine tonsil** between the palatoglossal and palatopharyngeal folds.
7. Observe that superiorly the palatoglossal folds converge medially towards the **uvula**, the midline extension of soft tissue descending from the **soft palate**. *Note that if the head bisection has been complete, the uvula will have been cut in the midline.*
8. Elevate the **tongue** and examine the **sublingual area** to identify the **frenulum of the tongue**, the mucosal fold connecting the inferior aspect of the tongue to the floor of the mouth in the midline.
9. To either side of the frenulum of the tongue, identify a **sublingual fold (plica sublingualis)** overlying the path of the submandibular duct.
10. Observe that the sublingual folds terminate medially at the associated bump of the **sublingual caruncle**.
11. On the surface of the sublingual caruncle, identify the **opening of submandibular duct**. *Note that in a living individual, deep lingual veins are visible beneath the mucosa on either side of the frenulum of the tongue, which may not be visible in the cadaver.*
12. Examine the inner surface of the cheek and make an effort to identify the opening of the parotid duct lateral to the 2nd maxillary molar.

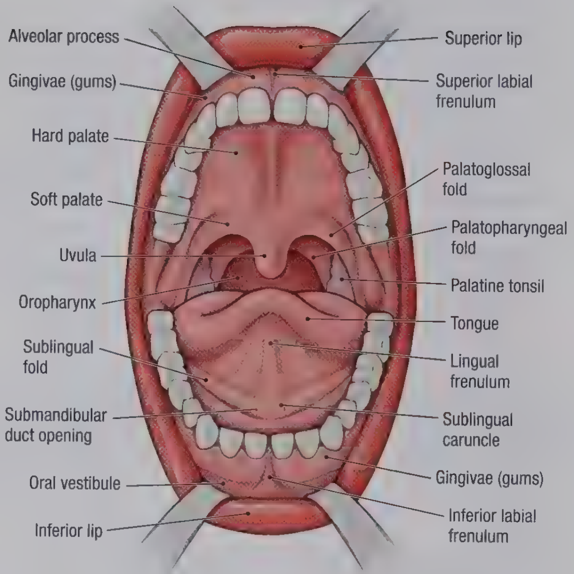


FIGURE 7.84 ● Oral cavity. Anterior view.

## Dissection Instructions

### Tongue

ATLAS 7.57B; VIDEO 7.18.1

1. Refer to FIGURE 7.85.
2. Examine the **tongue** and identify its **apex**, **body** (the anterior two-thirds), and **root** (the posterior one-third). Observe that the body and root of the tongue are delineated by the **terminal sulcus (sulcus terminalis)**.
3. Observe that the **lingual tonsils** lie posterior to the terminal sulcus on the root of the tongue.
4. On the **dorsum** of the tongue, follow the **median sulcus** posteriorly to the terminal sulcus and identify the **foramen cecum** in the midline.
5. Observe the surface of the dorsum of the tongue and identify the **lingual papillae**. *Note that there are four types of lingual papillae: vallate, filiform, fungiform, and foliate.*
6. Observe that the **body of the tongue** lies horizontally in the oral cavity and the **root of the tongue** lies more vertically. *Note that the root of the tongue constitutes the lower part of the anterior boundary of the oropharynx.*
7. At the root of the tongue, identify the **median glossoepiglottic fold**, a midline fold of mucosa between the dorsum of the tongue and the **epiglottis**.
8. Lateral to the median glossoepiglottic fold, identify the **lateral glossoepiglottic fold** between the dorsum of the tongue and the lateral border of the epiglottis.

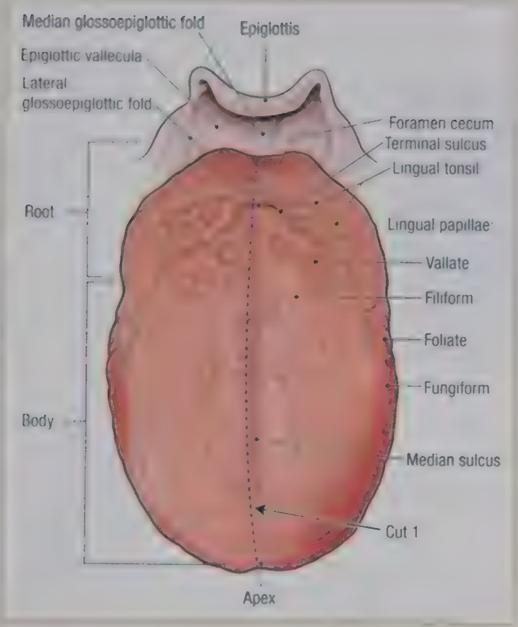

Median glossoepiglottic fold
Epiglottis
Epiglottic vallecula
Lateral glossoepiglottic fold
Foramen cecum
Terminal sulcus
Lingual tonsil
Root
Lingual papillae
Vallate
Filiform
Foliate
Fungiform
Body
Median sulcus
Cut 1
Apex

FIGURE 7.85 ● Dorsum of the tongue and incision for tongue bisection. Superior view.

9. Identify the **epiglottic valleculae**, the depressions between the median and right and left lateral glossoepiglottic folds.

## Bisection of the Tongue and Mandible

ATLAS 7.59B; VIDEO 7.18.2

1. Refer to FIGURE 7.85.
2. Use a scalpel to bisect the tongue in the median plane, beginning at the apex and proceeding toward the epiglottis (**Cut 1**), but do not yet cut through the epiglottis. Make the incision through the midline of the tongue through the bulk of the intrinsic muscles stopping at the level of the floor of the mouth.
3. Refer to FIGURE 7.86.
4. Turn the head to expose the submental triangle.
5. Use a saw to cut through the mandible in the median plane (**Cut 2**) making an effort to not cut too deeply and thus damage the underlying structures.
6. Use a scalpel to cut the **mylohyoid muscles** along their median raphe (**Cut 3**).
7. Use a probe to separate the mylohyoid muscles from deeper structures.

***Dissection Note:*** Do not allow the saw to pass between the genioglossus muscles on the deep side of the mandible and do not bisect the epiglottis, the hyoid bone, or the larynx at this time.

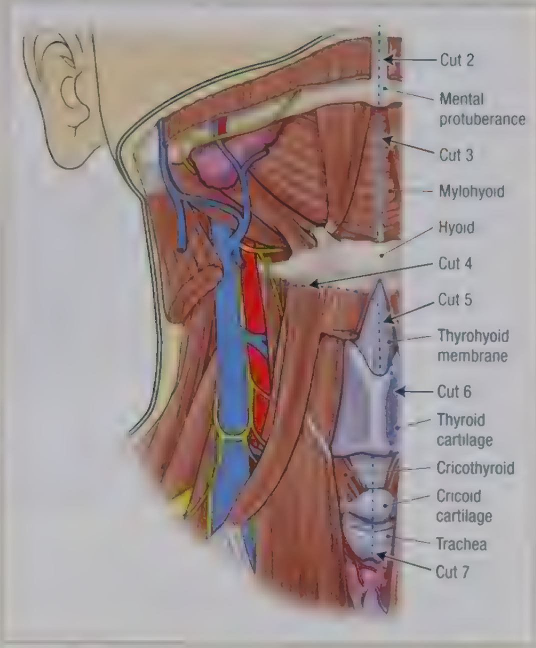

Cut 2
Mental protuberance
Cut 3
Mylohyoid
Hyoid
Cut 4
Cut 5
Thyrohyoid membrane
Cut 6
Thyroid cartilage
Cricothyroid
Cricoid cartilage
Trachea
Cut 7

FIGURE 7.86 ● Incision and cut lines for bisection of the mandible, floor of the mouth, and larynx. Anterior view.

## Sublingual Region

ATLAS 7.58C, 7.62A, 8.26B, 8.26C; VIDEO 7.18.3

***Dissection Note:*** Perform the following dissection sequence on only one side of the head.

1. Refer to FIGURE 7.87.
2. Identify the cut edge of the **mylohyoid muscle** in the sagittal view of the head.
3. Deep to the mylohyoid muscle, use blunt dissection to identify the **geniohyoid muscle**.
4. On the sectioned surface of the tongue, identify the **genioglossus muscle**.
5. Review the attachments, actions, and innervations of the geniohyoid and genioglossus muscles (see **TABLE 7.9**).
6. Carefully use a scalpel to incise the **sublingual mucosa** along the medial surface of the mandible beginning at the frenulum of the tongue and stopping near the 2nd mandibular molar.
7. Use forceps and blunt dissection to peel the cut edge of mucosa medially and remove it from the dissection field.
8. Identify the **sublingual gland** immediately deep to the mucosa and observe that the sublingual gland rests on the mylohyoid muscle. *Note that the*

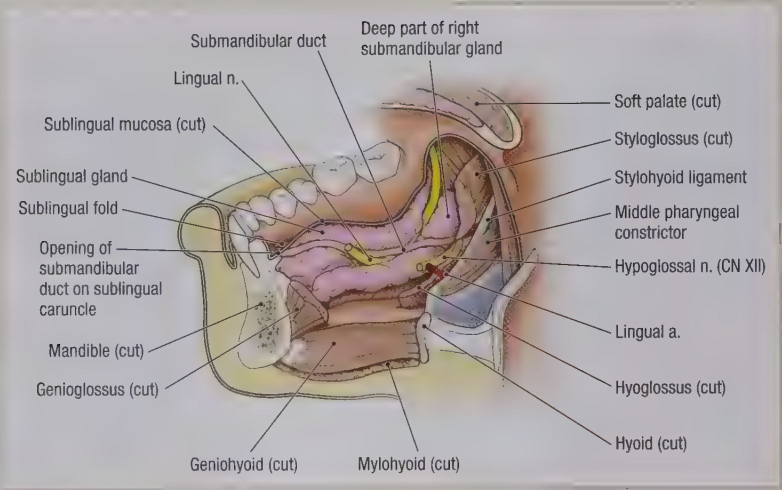

Submandibular duct
Deep part of right submandibular gland
Lingual n.
Sublingual mucosa (cut)
Sublingual gland
Sublingual fold
Opening of submandibular duct on sublingual caruncle
Mandible (cut)
Genioglossus (cut)
Geniohyoid (cut)
Mylohyoid (cut)
Soft palate (cut)
Styloglossus (cut)
Stylohyoid ligament
Middle pharyngeal constrictor
Hypoglossal n. (CN XII)
Lingual a.
Hyoglossus (cut)
Hyoid (cut)

FIGURE 7.87 ● Dissection of right sublingual region with tongue removed. Medial view.

*sublingual gland has about 12 short ducts that drain along the summit of the sublingual fold.*

9. Identify the **submandibular duct** along the medial side of the sublingual gland.
10. Use blunt dissection to follow the submandibular duct anteriorly to its **opening on the sublingual caruncle**.
11. Use blunt dissection to follow the submandibular duct posteriorly to the **deep part of the submandibular gland**. *Note that the deep part of the submandibular gland is located on the superior surface of the mylohyoid muscle.*
12. Turn the cadaver to expose the infratemporal fossa to find the **lingual nerve** and trace it into the sublingual region.
13. Observe that the lingual nerve first passes lateral, then inferior, then medial to the submandibular duct. *Note that the lingual nerve has several branches that supply the mucosa of the anterior two-thirds of the tongue with general sensation and taste fiber, and general sense to the mucosa on the floor of the mouth and the lingual side of the alveolar ridge.*
14. Near the 3rd mandibular molar, identify the **submandibular ganglion** suspended from the lingual nerve. *Note that the submandibular ganglion contains the postsynaptic parasympathetic cell bodies associated with the facial nerve (CN VII) to the submandibular and sublingual glands as well as taste to the anterior two-thirds of the tongue. Recall that the presynaptic parasympathetic fibers from the chorda tympani, a branch of the facial nerve, joined the lingual nerve in the infratemporal fossa to reach the submandibular ganglion.*
15. Refer to FIGURE 7.88.
16. Turn the cadaver so the submandibular triangle is exposed.
17. Use blunt dissection to define the attachment of the **mylohyoid muscle** to the hyoid bone.
18. Use scissors to detach the mylohyoid muscle from the hyoid bone and reflect the muscle superiorly.
19. Find the **hypoglossal nerve (CN XII)** and use a probe to trace it into the sublingual region where it passes between the deep part of the submandibular gland and the hyoglossus muscle.

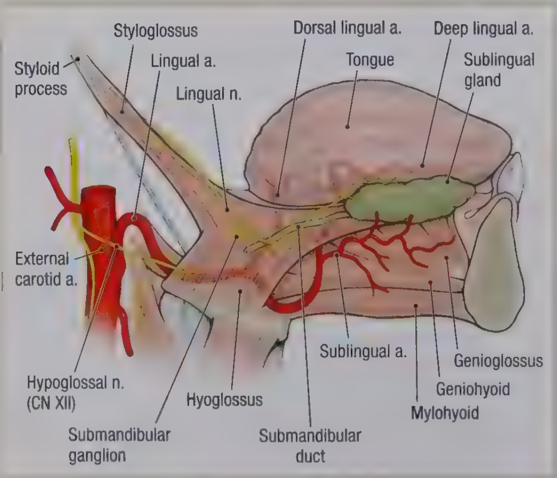

Styloglossus
Dorsal lingual a.
Deep lingual a.
Styloid process
Lingual a.
Tongue
Sublingual gland
Lingual n.
External carotid a.
Hypoglossal n. (CN XII)
Submandibular ganglion
Hyoglossus
Submandibular duct
Sublingual a.
Genioglossus
Geniohyoid
Mylohyoid

FIGURE 7.88 ● Extrinsic muscles and blood supply to the tongue with the right half of the mandible removed. Right lateral view.

20. Identify the **hyoglossus muscle**.
21. Observe that both the hypoglossal nerve and the **lingual nerve** pass between the hyoglossus muscle and the mylohyoid muscle to enter the sublingual region. *Note that the course of the hypoglossal nerve is inferior to the course of the lingual nerve.*
22. Near the superior end of the hyoglossus muscle, identify the **styloglossus muscle**.
23. Review the attachments, actions, and innervations of the hyoglossus and styloglossus muscles (see **TABLE 7.9**).
24. Identify the **intrinsic muscles of the tongue** and observe that they consist of **vertical, transverse, superior longitudinal**, and **inferior longitudinal groups of fibers**. *Note that the intrinsic muscles of the tongue and three extrinsic muscles of the tongue (styloglossus, genioglossus, and hyoglossus) are all innervated by the hypoglossal nerve (CN XII). The palatoglossus muscle, another extrinsic muscle of the tongue, is innervated by CN X via the pharyngeal plexus.*
25. Return to the carotid triangle and locate the **lingual artery** where it arises from the external carotid artery.
26. Follow the lingual artery superiorly until it passes medial to the hyoglossus muscle giving rise to the **dorsal lingual artery**.

**CLINICAL CORRELATION**

### Carotid Endarterectomy and Hypoglossal Nerve Injury

ATLAS 8.16

Carotid artery occlusion from atherosclerotic plaque buildup may lead to stenosis and thus require removal of the plaque surgically (carotid endarterectomy). As the hypoglossal nerve courses lateral to the carotid vessels, it is prone to damage during an open carotid endarterectomy. To test hypoglossal nerve function, a physician will ask the patient to protrude or "stick out" their tongue. As the genioglossus muscle protrudes the tongue and is innervated by the hypoglossal nerve, the functional side of the tongue will protrude normally, whereas the dysfunctional side protrudes less or not at all. Therefore, in testing for hypoglossal nerve lesions, the protruded tongue deviates toward the side of the nerve lesion.

27. Continue to follow the lingual artery to the point where the **sublingual artery** branches arise, and the name of the lingual artery changes to the **deep lingual artery**. *Note that the deep lingual artery is usually located within 5 mm of the inferior surface of the tongue.*

## Dissection Follow-up

1. Review the surface features of the tongue.
2. Review the innervation of the lingual mucosa.
3. Review the path of the submandibular duct from the submandibular triangle to the sublingual caruncle.
4. Trace the lingual nerve from the infratemporal fossa to the tongue, noting its relationship to the submandibular duct, hyoglossus muscle, and mylohyoid muscle.
5. Review the chorda tympani and the role that it plays in sensory innervation of the tongue and parasympathetic innervation of the submandibular and sublingual glands.
6. Trace the hypoglossal nerve from the base of the skull to the tongue, noting its relationships to arteries and muscles.
7. Review the attachments, actions, and innervations of the extrinsic muscles of the tongue and oral cavity in **TABLE 7.9**.
8. Review the origin and course of the facial and lingual arteries.
9. Return any reflected tissue back to anatomical position.

**TABLE 7.9 Muscles of the Tongue and Oral Cavity**

| *Muscle* | *Superior Attachments* | *Inferior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Geniohyoid | Inferior mental spine of mandible (anterior attachment) | Body of hyoid bone (posterior attachment) | Pulls the hyoid bone anteriorly | C1 via the hypoglossal n. (CN XII) |
| Genioglossus | Superior mental spine of the mandible (anterior attachment) | Hyoid bone and tongue (posterior attachment) | Depresses and protrudes tongue | Hypoglossal n. (CN XII) |
| Hyoglossus | Side and inferior aspect of tongue | Body and greater horn of the hyoid bone | Depresses and retracts tongue | |
| Styloglossus | Styloid process and stylohyoid ligament | Side and inferior aspect of tongue | Retracts tongue and draws it superiorly | |

Abbreviations: C, cervical vertebrae, CN, cranial nerve; n., nerve.

# LARYNX

## Dissection Overview

The larynx is contained in the visceral compartment of the neck anterior to the pharynx and medial and posterior to the thyroid gland. In its neutral position, the larynx is located at vertebral levels C3–C6, although its height varies during speech and swallowing. The skeleton of the larynx is responsible for maintaining a patent airway and consists of a series of articulated cartilages united by thin membranes. The glottis, a valve-like opening in the larynx, serves the dual function of controlling the airway and producing sound during phonation. The *intrinsic* muscles of the larynx control the glottis. The *extrinsic* muscles of the larynx (infrahyoid muscles, suprahyoid muscles, and stylopharyngeus muscle) control the position of the larynx in the neck.

The order of dissection will be as follows: The cartilages of the larynx will be studied. The mucosa of the larynx will be removed from the posterior part of the larynx to expose two intrinsic muscles. The left lamina of the thyroid cartilage will be removed to expose the remaining intrinsic muscles. The larynx will be opened, and the mucosal features will be studied. The nerves to the larynx will be reviewed.

### Skeletal Anatomy

### *Skeleton of the Larynx*

ATLAS 8.33

Use a model of the larynx and the cadaver to study the laryngeal cartilages and membranes.

1. Refer to FIGURE 7.89.
2. Identify the **epiglottic cartilage**, an unpaired cartilage that lies posterior to the tongue and hyoid bone.
3. Observe that the **stalk** of the epiglottic cartilage is attached to the inner surface of the angle formed by the thyroid laminae.
4. Inferior to the hyoid bone, identify the **thyroid cartilage** formed by two **laminae** joined in the anterior midline to form the **laryngeal prominence (Adam's apple)**.
5. Identify the **thyrohyoid membrane** between the superior border of the thyroid cartilage and the inferior border of the hyoid bone. *Note that when the suprahyoid and infrahyoid muscles move the hyoid bone, the larynx also moves because of the thyrohyoid membrane.*
6. Observe that the **superior horn** of the thyroid cartilage projects superiorly, whereas the **inferior horn** of the thyroid cartilage projects inferiorly and articulates with the **cricoid cartilage** at the **cricothyroid joints** through a synovial joint.
7. Observe that the **cricoid cartilage** is shaped like a ring, and its **lamina** is a broad flat area positioned posteriorly, and its **arch** is located anteriorly.

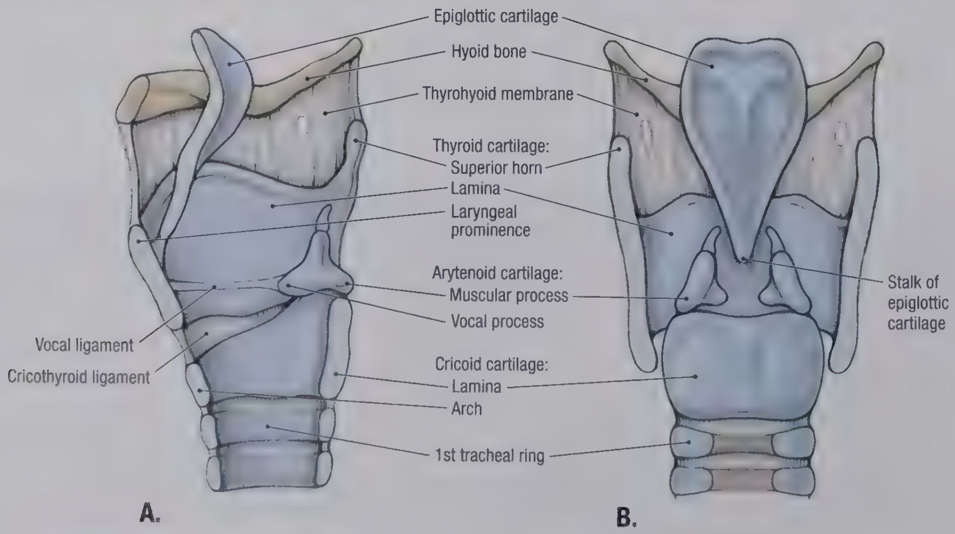

Epiglottic cartilage
Hyoid bone
Thyrohyoid membrane
Thyroid cartilage:
Superior horn
Lamina
Laryngeal prominence
Arytenoid cartilage:
Muscular process
Vocal process
Vocal ligament
Cricothyroid ligament
Cricoid cartilage:
Lamina
Arch
1st tracheal ring
Stalk of epiglottic cartilage
A.
B.

FIGURE 7.89 ■ Laryngeal skeleton. **A.** Medial view in midsagittal section. **B.** Posterior view.

8. On the posterior aspect of the superior border of the lamina of the cricoid cartilage, identify the **arytenoid cartilages**.
9. Observe that each arytenoid cartilage is pyramid shaped and that it articulates with the cricoid cartilage through a synovial joint.
10. On the arytenoid cartilage, identify the **muscular process**, the attachment site for intrinsic laryngeal muscles, and the **vocal process**, the posterior attachment site of the **vocal ligament**. The anterior end of each vocal ligament is attached to the inner surface of the thyroid cartilage at the angle formed by the laminae. *Note that each arytenoid cartilage can tilt anteriorly and posteriorly, slide toward the other (adduction), slide away from the other (abduction), and rotate.*

## Dissection Instructions

### Intrinsic Muscles of the Larynx

ATLAS 8.34B, 8.36; VIDEO 7.19.1

1. Refer back to FIGURE 7.86 and to FIGURE 7.90.
2. Identify the **cricothyroid muscle** on the external surface of the larynx and recall that it was innervated by external branch of the superior laryngeal while the internal branch pierced the **thyrohyoid membrane**.
3. To expose the posterior surface of the larynx, move the cadaver's head forward and allow the chin to rest on the thoracic wall.
4. Spread open the posterior wall of the pharynx to expose the posterior surface of the larynx and palpate the **lamina of the cricoid cartilage**.
5. Lateral to the lamina, identify the depression of the piriform recess.
6. Observe the vocal folds from a superior view and identify the **rima glottidis**, the interval between the vocal folds. *Note that the rima glottidis and the vocal folds collectively are called the glottis.*
7. Use blunt dissection to remove the mucosa from the piriform recess. Immediately deep to the mucosa, identify the **internal branch of the superior laryngeal nerve** and the superior laryngeal artery.
8. Observe that the **recurrent laryngeal nerve** enters the larynx by passing posterior to the **cricothyroid joint**. At this location, the name of the recurrent laryngeal nerve changes to **inferior laryngeal nerve**. *Note that although the name of the nerve changes at the cricothyroid joint to the inferior laryngeal nerve, physicians often refer to the entire length of the nerve as simply the recurrent laryngeal nerve.*
9. Use blunt dissection to strip the mucosa from the lamina of the cricoid cartilage and expose the **posterior cricoarytenoid muscle**. *Note that the*

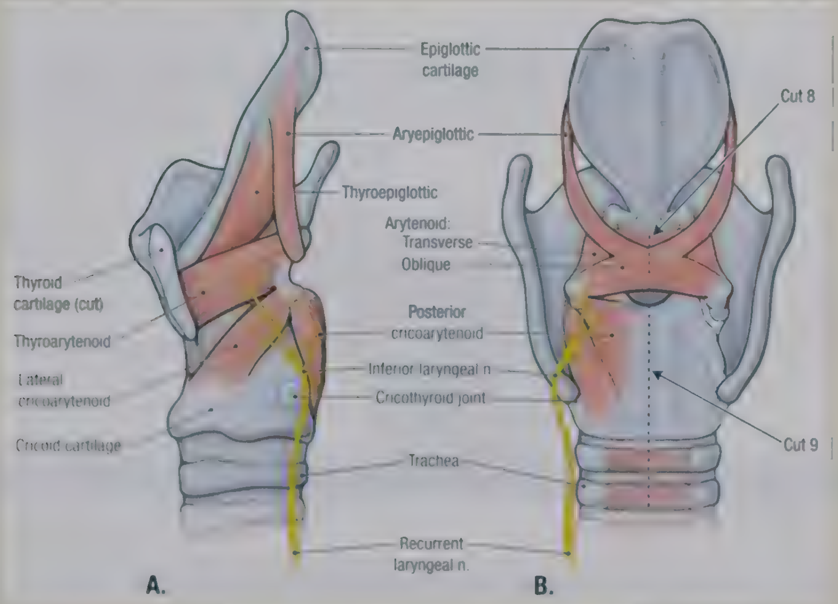

Epiglottic cartilage
Aryepiglottic
Thyroepiglottic
Arytenoid:
Transverse
Oblique
Posterior cricoarytenoid
Inferior laryngeal n.
Cricothyroid joint
Trachea
Recurrent laryngeal n.
Thyroid cartilage (cut)
Thyroarytenoid
Lateral cricoarytenoid
Cricoid cartilage
Cut 8
Cut 9
A.
B.

FIGURE 7.90 ● Intrinsic muscles of the larynx. **A.** Lateral view. **B.** Posterior view.

*posterior cricoarytenoid muscle is the only muscle that opens the rima glottidis.*

10. Superior to the posterior cricoarytenoid muscle, identify the **arytenoid muscle** attaching to both arytenoid cartilages.
11. Observe that the arytenoid muscle has **transverse fibers** and **oblique fibers**. *Note that the arytenoid muscle slides the arytenoid cartilages together (adduction of the vocal folds).*
12. On the left side only, use scissors to disarticulate the cricothyroid joint. *Note that the cricothyroid joint is a synovial joint that is reinforced by short ligaments.*
13. Return the head back to anatomical position.
14. On the left side only, use scissors to make a horizontal incision through the thyrohyoid muscle near its attachment to the hyoid (**Cut 4**) and reflect the muscle belly inferiorly. Similarly, if not already done previously, make horizontal incisions through the superior attachments of the sternohyoid and sternothyroid muscles on the left side and reflect them inferiorly.
15. Make a horizontal incision through the **thyrohyoid membrane** near its attachment to the hyoid and a vertical incision through the midline of the membrane (**Cut 5**), making an effort to spare the internal branch of the superior laryngeal nerve and the superior laryngeal artery.
16. Make a vertical incision through the left lamina of the thyroid cartilage 5 mm to the left of the midline (**Cut 6**). Reflect the thyroid lamina inferiorly and detach it from the cricothyroid muscle.
17. Medial to the thyroid lamina that was removed, identify the **lateral cricoarytenoid muscle**.
18. Identify the **thyroarytenoid muscle,** which is located superior to the lateral cricoarytenoid muscle. *Note that the vocalis muscle is formed by the medial fibers of the thyroarytenoid muscle though often difficult to distinguish in the cadaver. The vocalis muscle is attached to the vocal ligament and modifies the tension in localized parts of the vocal fold, modulating pitch.*
19. Make an effort to identify the delicate muscles of the larynx superior to the thyroarytenoid muscle, the **thyroepiglottic** and **aryepiglottic muscles.**
20. Review the attachments, actions, and innervations of the muscles of the larynx (see **TABLE 7.10**).
21. Continue to cut inferiorly in the anterior midline through the cricothyroid ligament, cricoid cartilage, and 1st tracheal ring (**Cut 7**).

## Interior of the Larynx

ATLAS 8.35, 8.36C; VIDEO 7.19.2

1. Refer to FIGURE 7.90.
2. To expose the posterior surface of the larynx, move the cadaver's head forward and allow the chin to rest on the thoracic wall.
3. In the posterior midline, cut the transverse and oblique arytenoid muscles (**Cut 8**).
4. Cut the cricoid cartilage and trachea in the midline posteriorly (**Cut 9**).
5. Refer to FIGURE 7.91.
6. Open the larynx and observe the **laryngeal cavity.**
7. Inspect the mucosa that lines the interior of the larynx and identify the **vestibular fold (false vocal fold)** superiorly and the **vocal fold (true vocal fold)** inferiorly, which contains the **vocal ligament.**
8. Identify the **vestibule,** the space superior to the vestibular folds; the **ventricle,** the depression between the vestibular fold and the vocal fold; and the **infraglottic cavity,** the region inferior to the vocal folds continuous with the trachea.

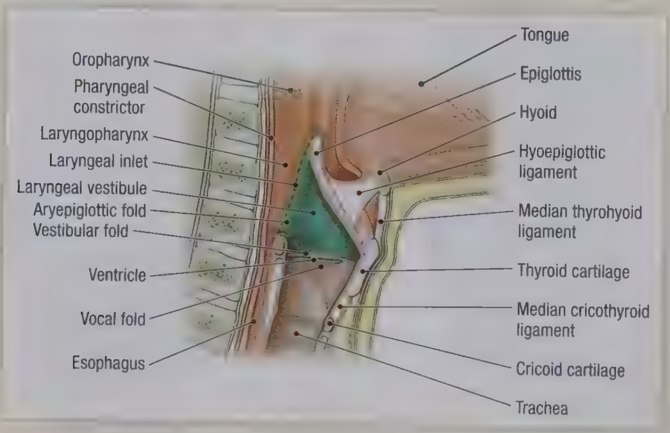


FIGURE 7.91 ● Mucosal features of the larynx in midsagittal section. Medial view.

**CLINICAL CORRELATION**

**Laryngospasm**

ATLAS 8.37

Laryngospasm is a spasmodic closure of the glottis, the opening between the vocal folds, and is life threatening. Spasms of the intrinsic laryngeal muscles that close the glottis may be produced by irritating chemicals, severe allergic reactions, and sometimes as a side effect of medications.

The vocal cords and larynx can be visualized using direct larygonscopy (viewed with a direct line of sight, including a rigid laryngoscope), or indirect laryngoscopy (viewed through a mirror or camera, including a flexible laryngoscope). Persistent hoarseness is an indication for laryngoscopy and may be caused by changes of the vocal folds, or may indicate that the recurrent laryngeal nerve is compromised in the thorax or neck.

9. Examine the **epiglottis** and note that it moves posteriorly during swallowing to close the laryngeal inlet.
10. Use a blunt probe to explore the space of the **ventricle** and, if present, the **saccule**, a small recess arising from the cavity of the ventricle.
11. Observe that the **internal branch of the superior laryngeal nerve** passes through the thyrohyoid membrane to provide sensory innervation to the mucosa of the vocal fold and the mucosa superior to the vocal folds.
12. Observe that the **external branch of the superior laryngeal nerve** remains external to the larynx to innervate the cricothyroid and inferior pharyngeal constrictor muscles.
13. Observe that the **inferior laryngeal branch of the recurrent laryngeal nerve** enters the larynx inferiorly to innervate all of the intrinsic muscles of the larynx, except the cricothyroid muscle, and provides sensory innervation to the mucosa inferior to the vocal folds.

## Dissection Follow-up

1. Use a cross-sectional drawing of the neck and the dissected specimen to review the relationship of the larynx to the vertebral column, carotid sheaths, and other cervical viscera.
2. Trace the right and left vagus nerves into the thorax and follow the recurrent laryngeal nerves from the thorax to the larynx noting the differences.
3. Review the blood supply to the larynx beginning at the external carotid artery.
4. Review the pattern of sensory innervation to the larynx.
5. Review the attachments, actions, and innervations of the intrinsic laryngeal muscles in **TABLE 7.10**.
6. Replace the head and reflected laryngeal tissue in their correct anatomical positions.

**TABLE 7.10 | Muscles of the Larynx**

| *Muscle* | *Superior Attachments* | *Inferior Attachments* | *Actions* | *Innervation* |
|---|---|---|---|---|
| Cricothyroid | Inferior margin and inferior horn of thyroid cartilage | Anterolateral surface of cricoid cartilage | Tilts the thyroid cartilage anteriorly to lengthen (tense) the vocal folds | External branch of the superior laryngeal n. (CN X) |
| Posterior cricoarytenoid muscle | Muscular process of arytenoid cartilage | Posterior surface of the lamina of cricoid cartilage | Rotates arytenoid cartilage laterally to abduct vocal folds | Inferior laryngeal n. (continuation of the recurrent laryngeal n.) (CN X) |
| Lateral cricoarytenoid muscle | | Arch of cricoid cartilage | Rotates arytenoid cartilage medially to adduct vocal folds | |
| Thyroarytenoid | | Posterior surface of thyroid cartilage | Tilts arytenoid cartilage anteriorly to relax vocal folds | |

Abbreviations: CN, cranial nerve; n., nerve.

# EAR

## Dissection Overview

The ear is composed of three parts: external ear, middle ear, and internal ear. The external ear consists of the auricle and the external acoustic meatus. The middle ear (tympanic cavity) is enclosed within the temporal bone and contains the ossicles (bones of the middle ear). The internal ear (vestibulocochlear organ) is the neurologic part of the ear and is contained within the petrous portion of the temporal bone.

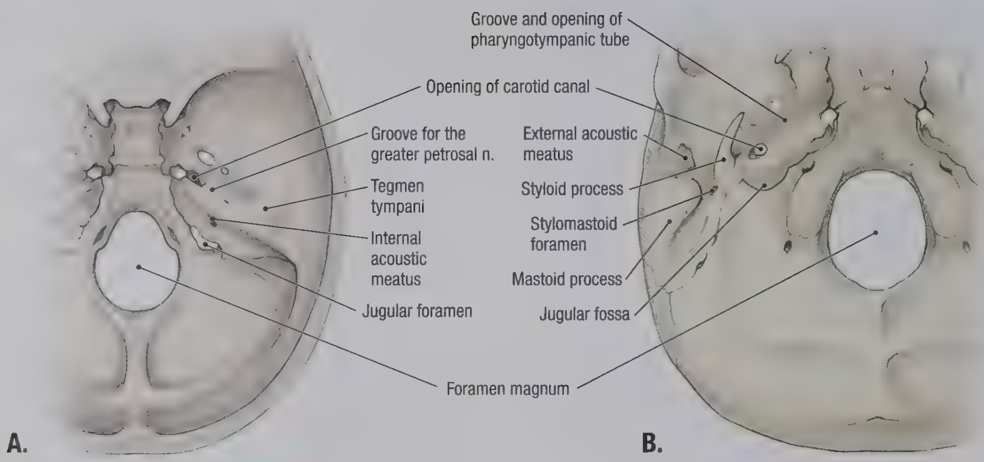

Groove and opening of pharyngotympanic tube
Opening of carotid canal
Groove for the greater petrosal n.
External acoustic meatus
Tegmen tympani
Styloid process
Stylomastoid foramen
Internal acoustic meatus
Mastoid process
Jugular foramen
Jugular fossa
Foramen magnum
A.
B.

FIGURE 7.92 ● Temporal bone. **A.** Superior view. **B.** Inferior view.

The order of dissection will be as follows: The parts of the external ear will be examined. The facial nerve will be followed from the posterior cranial fossa into the internal acoustic meatus, and the roof of the tympanic cavity will be removed. The auditory ossicles will be identified, and one ossicle will be removed. The temporal bone will be cut to reveal the medial and lateral walls of the tympanic cavity. The tympanic membrane will be studied. Features of the medial wall of the tympanic cavity will be examined.

## Skeletal Anatomy

### *Skeleton of the Ear*

On a skull with the calvaria removed, review the following skeletal features.

### *Temporal Bone*

ATLAS 7.3A, 7.5A, 7.90A

1. Refer to FIGURE 7.92.
2. On the floor of the middle cranial fossa, identify the **tegmen tympani**, the portion of temporal bone that forms the roof of the tympanic cavity.
3. Identify the **groove for the greater petrosal nerve** coursing medially near the roof of the carotid canal.
4. On the surface of the temporal bone within the posterior cranial fossa, identify the **internal acoustic meatus**.
5. From a lateral view, identify the **external acoustic meatus** anterior to the **mastoid process**.
6. Rotate the skull and, from an inferior view, identify the **stylomastoid foramen** between the mastoid process and the **styloid process**.
7. Medial to the stylomastoid foramen, identify the **jugular fossa**, the depression immediately anterior to the jugular foramen. Observe the close relationship of the jugular fossa and the **opening of the carotid canal**.
8. Anterior to the round opening of the **carotid canal**, identify the irregular borders leading to the bony portion of the **pharyngotympanic tube**.

## Surface Anatomy

### *External Ear*

ATLAS 7.81C

1. Refer to FIGURE 7.93.
2. Examine the **auricle (pinna)**, the visible portion of the external ear of the cadaver.
3. Identify the **helix**, the rim of the auricle. Observe that the helix is paralleled by a more anteriorly located rounded prominence of auricular cartilage, the **antihelix**.

4. Follow the helix superiorly and anteriorly until it curves around the antihelix and leads to the **concha**, the deepest part of the auricle.
5. Anterior to the opening of the **external acoustic meatus**, identify the **tragus**. Observe that the tragus is directed posteriorly toward the **antitragus**.
6. On the inferior aspect of the auricle, identify the **lobule of the auricle (earlobe)**. Observe that the **auricular cartilage** gives the auricle its shape. *Note that there is no cartilage in the lobule.*
7. Palpate the auricular cartilage and verify that it is continuous with the cartilage of the external acoustic meatus. *Note that the external acoustic meatus begins at the deepest part of the concha and ends at the tympanic membrane (a distance of about 2.5 cm in adults). The wall of the outer one-third of the external acoustic meatus is cartilaginous and the inner two-thirds is bony.*

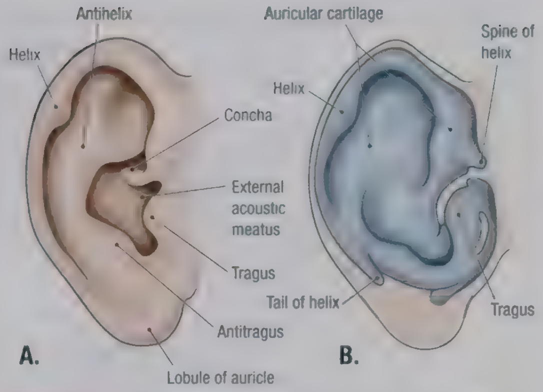


FIGURE 7.93 ■ **A.** Surface anatomy of the external ear. **B.** Auricular cartilage. Lateral views.

## Dissection Instructions

### Tympanic Cavity from the Superior Approach

ATLAS 7.87; VIDEO 7.20.1

***Dissection Note:*** The tympanic cavity (middle ear) will be approached by removing the tegmen tympani portion of the floor of the middle cranial fossa on only one side of the head. Remember to wear eye protection when cutting bone.

1. Refer to FIGURE 7.94.
2. If the dura mater is still present in the middle cranial fossa of the cadaver, peel it off the superior surface of the temporal bone beginning at the superior border of the petrous part of the temporal bone, peeling the dura mater in an anterior direction.
3. Look for the **greater petrosal nerve** in the groove for the greater petrosal nerve. *Note that the greater petrosal nerve lies between the dura mater and the bone.*
4. In the posterior cranial fossa, identify the **facial nerve (CN VII)** and the **vestibulocochlear nerve (CN VIII)** as they enter the internal acoustic meatus.
5. Use a hammer and the tip of a probe or small chisel and gently break through the roof of the internal acoustic meatus. Follow the **facial** and **vestibulocochlear nerves** laterally as they pass through the internal acoustic meatus, remaining superior to the nerves when cutting the internal acoustic meatus.
6. Remove the small portions of the broken tegmen tympani and follow the facial nerve laterally until it makes a sharp bend in the posterior direction and identify the **geniculate ganglion**.
7. Make an effort to identify the origin of the greater petrosal nerve from the geniculate ganglion within the bone. *Note that the geniculate ganglion contains cell bodies of sensory neurons. The greater petrosal nerve carries presynaptic parasympathetic fibers to the pterygopalatine ganglion for innervation of the mucous membranes of the nasal and upper oral cavities and to the lacrimal gland. The presynaptic parasympathetic nerve fibers do not synapse in the geniculate ganglion.*
8. Follow the greater petrosal nerve and observe that it passes inferiorly and medially in the **groove for the greater petrosal nerve** (on the surface of the temporal bone).
9. Observe that the greater petrosal nerve joins the deep petrosal nerve to form the **nerve of the pterygoid canal** on the surface of the internal carotid artery after it emerges from the carotid canal near the opening of the foramen lacerum. *Note that the nerve of the pterygoid canal carries the presynaptic fibers of the greater petrosal nerve to the pterygopalatine ganglion.*
10. Observe that at the geniculate ganglion, the facial nerve travels a short distance in a posterolateral direction and then turns inferiorly to exit the skull at the stylomastoid foramen via the facial canal. Do not attempt to follow the facial nerve through the temporal bone.
11. Identify the location of the **cochlea** anterior to the internal acoustic meatus in the angle formed by the facial nerve, the geniculate ganglion, and the greater petrosal nerve.
12. Remove a portion of the tegmen tympani anterior to the facial nerve to identify the modiolus of the cochlea, the central axis. *Note that the visibility of the modiolus in the cadaveric largely depends on the plane of the cut.*
13. In the dissected cadaver, remove a portion of the tegmen tympani posterior to the facial nerve and identify the **semicircular canals**. The semicircular canals may be seen as a series of tiny holes in the bone posterior to the internal acoustic meatus.

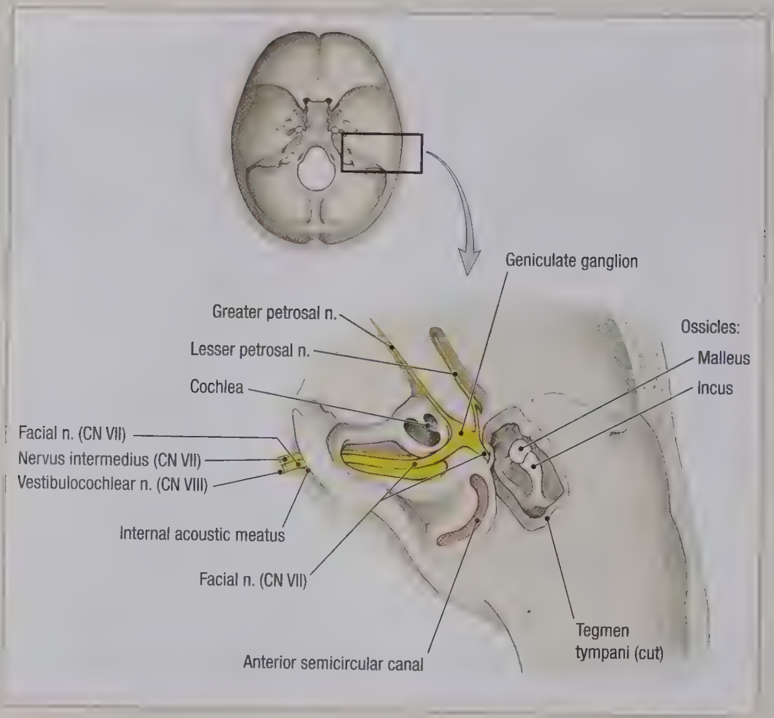

Geniculate ganglion
Greater petrosal n.
Lesser petrosal n.
Cochlea
Facial n. (CN VII)
Nervus intermedius (CN VII)
Vestibulocochlear n. (CN VIII)
Internal acoustic meatus
Facial n. (CN VII)
Anterior semicircular canal
Ossicles:
Malleus
Incus
Tegmen tympani (cut)

FIGURE 7.94 ■ Right middle ear after removal of the tegmen tympani. Superior view.

14. Open the **tympanic cavity** using forceps to remove additional portions of the **tegmen tympani** laterally and confirm it is an air-filled space within the temporal bone.
15. Within the tympanic cavity, identify the **auditory ossicles**.
16. Observe that the **malleus** is attached to the tympanic membrane, the **incus** occupies an intermediate position, and the **stapes** is the most medial of the auditory ossicles. *Note that the malleus and incus should easily be seen from the superior view but that the stapes is located more inferiorly and may be harder to see.*
17. Use fine forceps to remove the incus. Leave the malleus attached to the tympanic membrane.
18. Looking down from above, identify the **tympanic membrane** on the lateral wall of the tympanic cavity. Attempt to identify the tendon of the tensor tympani muscle, a thin strand of tissue that spans from the medial wall of the tympanic cavity to the handle of the malleus.

## Sectioning the Tympanic Cavity

ATLAS 7.88

***Dissection Note:*** The following dissection approach is intended for use on a decalcified temporal bone. If a decalcified temporal bone is not available, you may skip the following dissection protocol and proceed to the middle ear sequence.

1. Refer to FIGURE 7.95.
2. With the blade angled parallel to the internal surface of the tympanic membrane, insert a scalpel blade into the opening created by removing the incus.

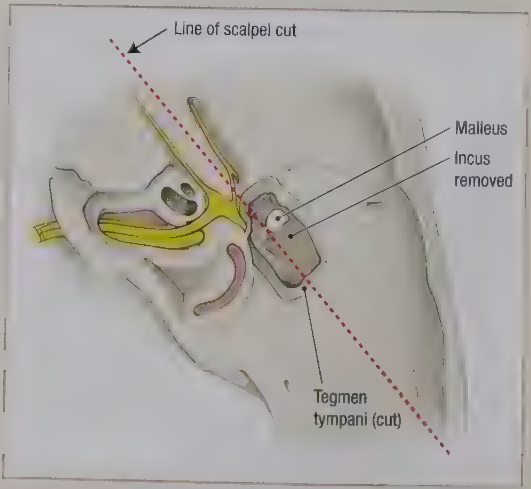

Line of scalpel cut
Malleus
Incus removed
Tegmen tympani (cut)

FIGURE 7.95 ■ Angle of cut to separate the medial and lateral walls of the tympanic cavity. Superior view.

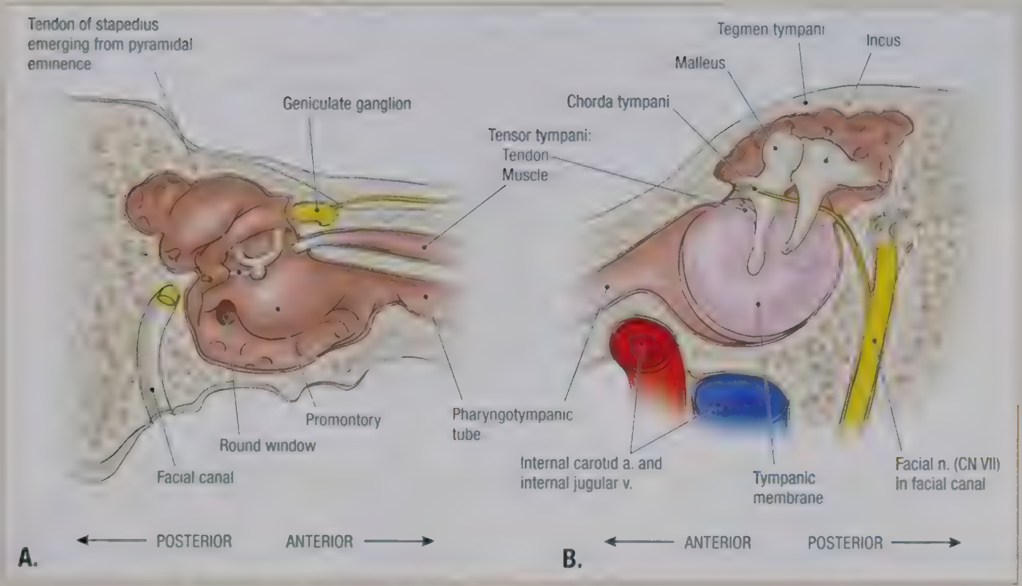

Tendon of stapedius emerging from pyramidal eminence
Geniculate ganglion
Tensor tympani:
Tendon
Muscle
Promontory
Round window
Facial canal
Pharyngotympanic tube
POSTERIOR
ANTERIOR
A.
Tegmen tympani
Incus
Malleus
Chorda tympani
Internal carotid a. and internal jugular v.
Tympanic membrane
Facial n. (CN VII) in facial canal
ANTERIOR
POSTERIOR
B.

FIGURE 7.96 Walls of the right tympanic cavity opened like a book. **A.** Medial wall. **B.** Lateral wall.

Make a cut that extends anteriorly down the pharyngotympanic tube that divides the middle ear into medial and lateral walls. *Note that the cut through the pharyngotympanic tube should course parallel to the superior border of the petrous part of the temporal bone.*

3. Refer to FIGURE 7.96.
4. On the lateral wall of the tympanic cavity, observe the tympanic membrane and identify the **chorda tympani**. Observe that the chorda tympani passes between the malleus and the incus.
5. On the medial wall of the tympanic cavity, identify the elevation of the **promontory**.
6. Superior to the promontory, identify the **stapes** still attached to the **oval window (fenestra vestibuli)**. Look for the **stapedius tendon**, about 1 mm long, passing from the pyramidal eminence to the stapes. *Note that the stapedius muscle is innervated by the facial nerve (CN VII).*
7. Inferior to the stapes, identify the **round window (fenestra cochleae)** posteroinferior to the promontory.
8. Identify the **tensor tympani muscle**, which attaches to the pharyngotympanic tube and sphenoid bone medially and to the manubrium (handle) of the malleus laterally.
9. Observe that the tendon of the tensor tympani muscle crosses the tympanic cavity. The tensor tympani muscle is innervated by the mandibular division of the trigeminal nerve (CN $V_3$).
10. Observe that the tympanic cavity and its associated recesses and air cells are covered with mucous membrane. *Note that the tympanic branch of the glossopharyngeal nerve (CN IX) innervates the mucous membrane of the tympanic cavity and that it forms the tympanic plexus under the mucosa covering the promontory.*

## Walls of the Tympanic Cavity

ATLAS 7.84, 7.85, 7.86

1. Refer to FIGURE 7.97 to familiarize yourself with the features of the tympanic cavity.
2. Observe that the tympanic cavity is separated from the external acoustic meatus by the **tympanic membrane** and from the middle cranial fossa by the **tegmen tympani**.
3. Identify the **lateral wall** of the tympanic cavity and observe that it is formed by the **tympanic membrane**.

### CLINICAL CORRELATION

**Otitis Media**

ATLAS 7.85

An "ear infection" is typically caused by inflammation of the middle ear cavity (otitis media), which may occur rapidly with ear pain, difficulty sleeping, loss of appetite, and fever, or may be painless with effusion (fluid accumulation) over time. A burst "ear drum" or perforation of the tympanic membrane may result from otitis media, foreign bodies entering the external acoustic meatus, trauma, or increased pressure.

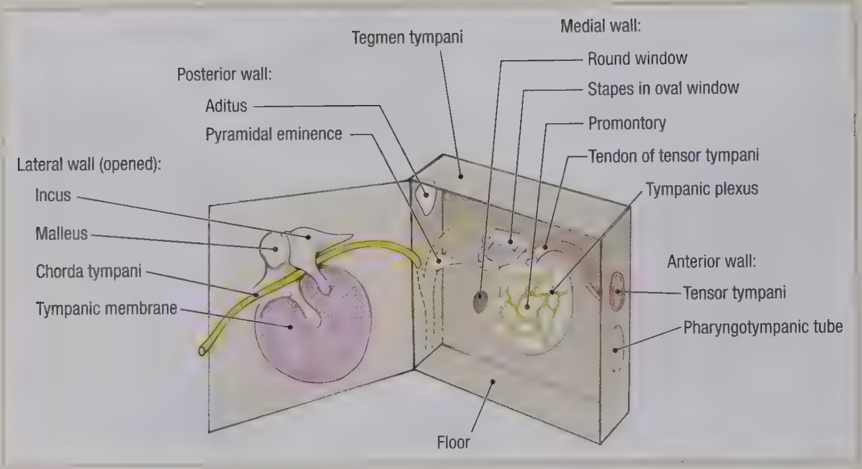

Tegmen tympani
Medial wall:
Round window
Stapes in oval window
Promontory
Tendon of tensor tympani
Tympanic plexus
Posterior wall:
Aditus
Pyramidal eminence
Lateral wall (opened):
Incus
Malleus
Chorda tympani
Tympanic membrane
Anterior wall:
Tensor tympani
Pharyngotympanic tube
Floor

FIGURE 7.97 ■ Schematic of the walls of the right tympanic cavity with the lateral wall opened. Anterolateral view.

4. Along the superior aspect of the **posterior wall** of the tympanic cavity, identify the **aditus**, an opening into the **mastoid air cells** within the mastoid process.
5. Identify the **medial wall** of the tympanic cavity. Observe that the medial wall contains the rounded **promontory** and the **oval window (fenestra vestibuli)**, which contains the base (footplate) of the **stapes**.
6. Observe that the **anterior wall** of the tympanic cavity contains the opening of the **pharyngotympanic tube**.
7. Identify the **superior wall (roof)** of the tympanic cavity and observe that it is formed by the tegmen tympani of the temporal bone.
8. Observe that the **inferior wall (floor)** of the tympanic cavity is closely related to the **jugular fossa** and the **jugular bulb**.

## Dissection Follow-up

1. Review the external appearance of the tympanic membrane.
2. Relate the tympanic membrane to the handle of the malleus and the chorda tympani.
3. Review the course of the facial nerve from the internal acoustic meatus to the facial muscles.
4. Review the course of the greater petrosal nerve from the geniculate ganglion to the pterygopalatine ganglion and summarize the distribution of the postsynaptic axons that arise in the pterygopalatine ganglion.
5. Review the location of the cell bodies for the sensory axons of special sense related to the chorda tympani.
6. Review all branches of the glossopharyngeal nerve, including those that give rise to the lesser petrosal nerve.
7. Return all reflected tissue to its anatomical position.

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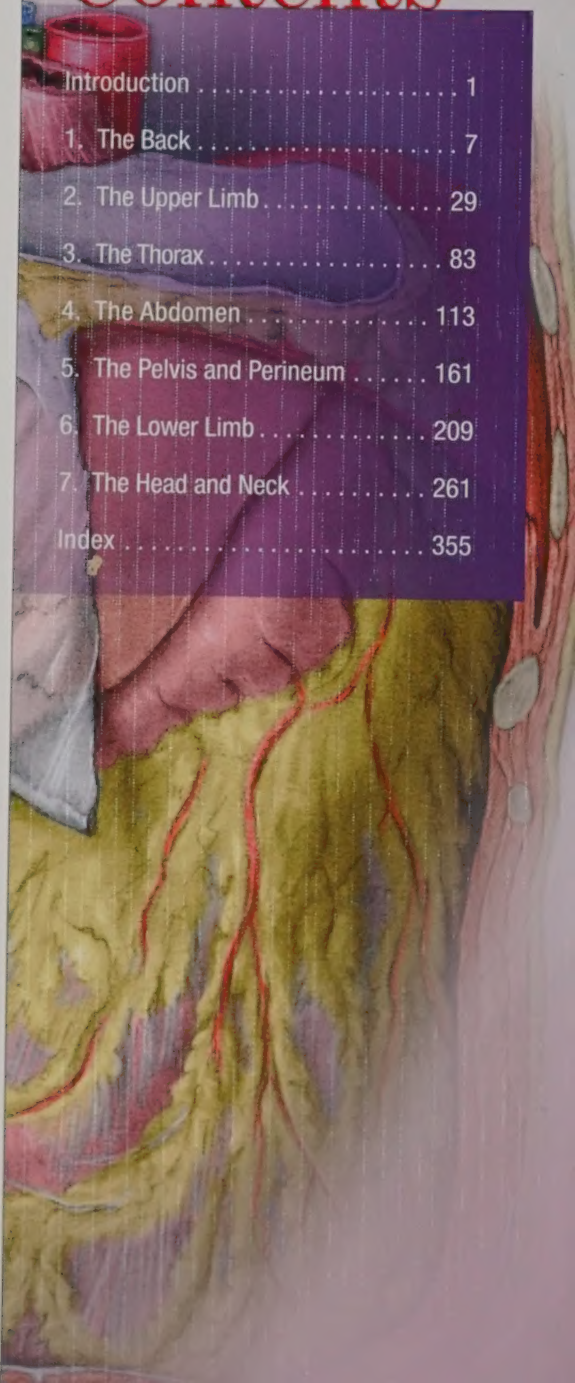

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